

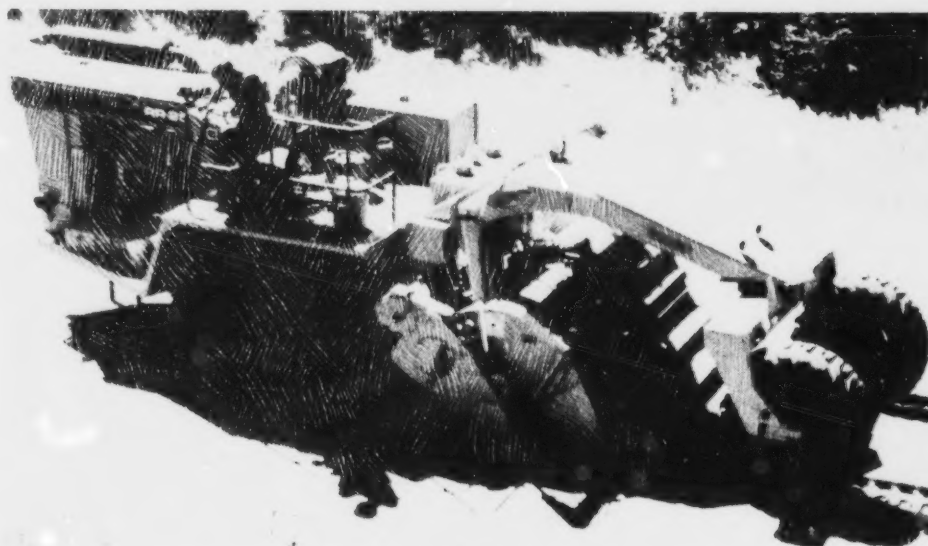


Ministry
of
Transportation

Ontario

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The Use of Recovered Bituminous & Concrete Materials in Granular and Earth



Engineering
Materials
Office

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**The Use of Recovered
Bituminous & Concrete Materials
in Granular and Earth**

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EXECUTIVE SUMMARY

This report deals with the use of recovered concrete and bituminous material as a substitute for unbound granular material in highway bases, sub-bases and shoulders.

Recovered construction materials have been in use by various authorities in North America for many years. In Ontario, only certain municipalities have used recovered concrete products in granular base to any great extent. The Ministry of Transportation (MTO) has considerable experience with the use of recovered bituminous material (RBM) as a substitute for granular base from as early as 1971.

In keeping with the Provincial Government policy on Sustainable Development, MTO encourages the use of recovered construction materials in highway contracts. This policy will (i) reduce the use of virgin aggregates which are a non-renewable resource; (ii) reduce the accumulation of waste products; and (iii) use a product that is probably superior to standard granular materials. This report compiles and analyses MTO experience to date and documents the results of laboratory testing undertaken on these materials. It also provides recommendations and special provisions covering the use of these materials in highway construction.

Recovered bituminous material has been used 100 per cent as granular base and shoulder material on MTO projects. It has also been both blended off-site and pulverized in-place with granular materials. Performance has in general been most satisfactory, although a blended product appears preferable to 100 per cent RBM in granular base applications. Off-site, the required blend and gradation can be achieved by controlled crushing, mixing and stockpiling procedures. In-place, the blend and gradation can be obtained by good pulverizing techniques, such as controlled speed and spacing of the cutting teeth. Fine grading a compacted RBM surface is a problem, but this can be eliminated by offering incentives to pave as soon as possible after compaction.

Laboratory data indicates that the strength of the blended product will be of the same order as that of a standard granular, and may increase with time. The permeability is of the same order as compacted granular, and in some cases, higher.

It is recommended that contracts to be constructed in the near future use a 30 per cent maximum RBM content. Trial contracts for 1990 construction should use a 40 per cent maximum RBM content. In addition, test sections should be considered to compare the performance of 50, 75 and 100 per cent RBM in granular base.

RÉSUMÉ

Le présent rapport traite de l'utilisation du béton et des matériaux bitumineux recyclés pour remplacer les matériaux granulaires non liés dans la base, le soubassement et l'accotement des routes.

En Amérique du Nord, les matériaux de construction recyclés sont utilisés par des nombreux groupes depuis plusieurs années. En Ontario, quelques municipalités seulement utilisent en grande partie des produits de béton recyclé dans la base granulaire. Le ministère des Transports (MTO) a acquis, depuis 1971, une vaste expérience dans l'utilisation de matériaux bitumineux recyclés (MBR) pour remplacer la base granulaire.

Conformément à la politique gouvernementale en matière de développement durable, le MTO favorise l'utilisation de matériaux de construction recyclés dans les contrats routiers. Cette politique permettra (i) de réduire l'utilisation d'agréats purs non renouvelables; (ii) de réduire l'accumulation de déchets; et (iii) d'utiliser un produit qui est sans doute supérieur aux matériaux granulaires standards. Ce rapport fait état de l'expérience acquise jusqu'à présent par le MTO, en fait l'analyse et documente les résultats des essais de ces matériaux en laboratoire. Il contient également des recommandations et des dispositions spéciales sur l'utilisation de ces matériaux dans la construction routière.

Dans le cadre de projets du MTO, on n'a utilisé que des matériaux bitumineux recyclés pour former la base granulaire et l'accotement. De plus, ces matériaux ont été mélangés avec des matériaux granulaires hors du site de construction et pulvérisés sur place. Les résultats obtenus ont, en général, été des plus satisfaisants, bien qu'il semble préférable d'utiliser un produit mélangé dans la base granulaire plutôt qu'un seul produit. La préparation et le dosage hors du site de construction sont effectués par broyage, mélange et stockage dirigés. Sur place, le mélange et le dosage sont effectués au moyen de techniques de pulvérisation tenant compte de la vitesse et de l'espacement des dents. Le nivellement final d'une surface compacte de matériaux bitumineux recyclés pose un problème qui peut être réglé en incitant les constructeurs à paver la surface dès que possible après le compactage.

Les données obtenues en laboratoire révélant que le produit mélangé sera aussi résistant que les matériaux granulaires standards et que cette résistance pourrait s'accroître avec le temps. La perméabilité est du même ordre que celle des matériaux granulaires compacts, voire supérieure dans certains cas.

On recommande que les projets de construction qui seront réalisés dans un proche avenir prévoient une teneur en matériaux bitumineux recyclés d'au plus 30 pour 100. Les contrats d'essai pour les projets de construction prévus pour 1990 devraient prévoir une teneur en matériaux bitumineux recyclés d'au plus 40 pour 100. En outre, on devrait envisager le recours à des sections d'essai pour comparer le comportement de la base granulaire lorsque la teneur en matériaux bitumineux recyclés est de 50, 75 et 100 pour 100.

THE USE OF RECOVERED CONCRETE AND BITUMINOUS MATERIALS IN GRANULAR AND EARTH

1. INTRODUCTION

In keeping with the Provincial Government policy on Sustainable Development, the Ministry of Transportation encourages the use of recovered construction materials in highway contracts. This report documents MTO experiences with the use of recovered materials in granular, and discusses laboratory test results and special provisions designed to promote their use in the future. This policy will i) reduce the use of virgin aggregates which are a non-renewable resource; ii) reduce the accumulation of waste products and iii) use a product that is probably superior to standard granular materials.

Recovered construction materials have been in use by certain authorities in North America for some time. In Ontario, only municipalities have used recovered Portland cement concrete material in granular to any great extent. The Ministry has little experience with this material. However, the Ministry has considerable experience with the use of recovered bituminous material as a substitute for granular.

In September of 1988, the Ministry of the Environment (Waste Management Branch) issued a position paper which addressed the management of materials generated through road maintenance and construction. Among these were concrete and asphalt materials. They were considered under two categories:

a) Materials not considered to be waste:

- asphalt and concrete being stockpiled for reuse in road building materials at highway construction sites.

b) Inert Fill:

- concrete and other construction materials can be managed as inert fill provided they are placed in an area where there is a demonstrated need for fill material and the site would be top covered. Consideration should be given in the case of asphalt materials that water supplies are protected.

Any material not considered for use under the above would be treated as a waste and would have to be disposed of at an approved site.

Special Provision 199F30 (November 1988) outlines M.T.O. requirements for management of excess or surplus materials and covers the above uses.

In order to promote and coordinate the use of recovered materials by MTO, the following activities were implemented:

- 1) A Work Group was formed during 1988 to develop Special Provisions for Trial Ministry Contracts in 1990. The mandate of the group was to maximize the use of recovered bituminous pavement and concrete materials by offering the Contractor a wide variety of options.
- 2) In order to make the most effective use of available resources, the Quality Assurance Systems Committee requested late in 1988 that Special Provisions be developed for use on all Ministry Contracts in 1989 using similar options to those proposed for the trial contracts.

2. PURPOSE OF THE STUDY

In order to develop a strategy for the use of recovered bituminous and concrete materials, it was decided to initiate three programs:

- 1) Investigate information from Ministry contracts where recovered materials had been used in granular. This would include construction techniques, problems occurring during construction and performance information, if available.
- 2) Carry out laboratory testing to evaluate a number of parameters of recovered bituminous material mixed with standard granular. These were to include gradation, compaction, California bearing ratio and permeability. Results would be compared with those obtained from standard granular aggregates.
- 3) Develop Special Provisions which would be applicable on a Ministry-wide basis and would cover the majority of uses for recovered materials.

3. DEFINITIONS

For the purpose of this report the following terms and definitions are used:

a) Recycled Crushed Concrete

This consists of Portland cement concrete from sidewalks, driveways, structures, curb and gutter and a limited amount of pavement. It is processed by crushing, removing deleterious material such as metal, plastic and paper, screening and stockpiling for use.

b) Reclaimed Asphalt Pavement (R.A.P.)

This is bituminous pavement which has been recovered (usually by milling) and is to be used in part in new pavement. Anything surplus to recycling needs on a particular contract is available for other uses.

c) Recovered Bituminous Material (R.B.M.)

This is bituminous pavement which is intended for use other than in R.A.P. It is considered to have been recovered by processes such as milling, full depth pick up or pulverizing in place. It may consist of hot mix, mulch, surface treatment, or any combination of these. It may be used as a substitute for granular materials or in fill.

d) Pulverized Material

This term is applied to the material resulting from the pavement being pulverized and mixed into the underlying granular by mechanical means. The depth of processing may be varied to suit the pavement depth or blend ratio required. Control of the per cent R.B.M. in the final product may be difficult to achieve due to varying pavement thickness and/or depth of pulverizing.

e) Processed Material

This term is applied to material resulting from the pavement being picked up, removed from the road, crushed and combined with standard granular material in the required percentage. The standard granular material must meet MTO quality requirements. Control of the final product is relatively easy to achieve as the amounts of material combined can be monitored.

4. USE OF RECOVERED MATERIALS IN GRANULAR

4.1 Recovered Concrete Material

Various authorities in the United States have been recycling Portland cement concrete materials by crushing for a number of years. Typically the material is picked up, taken to a crusher located near the construction site, crushed and used as a substitute for granular base.

A plant located in Hicksville, New York, began producing recycled concrete aggregates in 1977 and more than 1 million cubic yards of material were produced up to the end of 1982. During this time, the material was monitored by the producer for physical characteristics from stockpile samples. A summary of this testing was published in the Transportation Research Record by Petrarca and Galdiero in 1983 (1). Figure 1 shows the average gradation of all samples and some of the physical properties are presented in Table 1.

In-situ breaking of concrete pavement has also been carried out in some States, with the material being left in place and new bituminous or concrete surface courses applied.

The Engineering Materials Office of the Ministry carried out testing on crushed concrete material in 1985 after enquiries from consultants and municipalities. The testing indicated that the crushed concrete product had very similar properties to standard granular materials and would behave in a similar manner. Typical gradations are shown in Figure 1 and the physical characteristics are presented in Table 2.

To date, recovered concrete material has not been used on Ministry projects, due to the fact that insufficient quantity is produced to meet normal needs. However, it has found successful application crushed and used as a base material under municipal roads and concrete floors in new structures.

4.2 Recovered Bituminous Material

In 1971, a road test site was selected on Highway 11 at Trout Creek, about 29 km south of North Bay. The existing pavement was in need of rehabilitation or replacement. Eight different treatments for the underlying base material were proposed to investigate the prevention of thermal reflection cracking in asphalt overlays. Construction was carried out between August and October, 1971. Two of the treatments used consisted of pulverizing the existing pavement and using it as a granular base. One of these treatments also included the addition of 3 % of MC-250 cutback to enrich the material. Details of the above may be found in a report by Kher in 1977 (2).

Field surveys carried out in November of 1978 noted that the two test sections treated by pulverizing had the lowest incidence of reflection cracks. This data is reported in an addendum to the 1977 report (3).

Recovered bituminous pavement has been used on a number of Ministry contracts around the province during the period 1976 to date. These have varied from experimental use as shouldering to complete reconstruction by mixing with granular off-site or in-place. The details of this work are outlined by region below and also summarized in Table 3:

4.2.1 Northern Region:

Processing:

Contract 76-03 on Hwy. 11 called for the existing pavement to be picked up full depth, crushed and replaced 100 % as granular base for the full pavement width. The expectation was that the R.B.M. would contribute some additional strength, so one less lift of hot mix was placed i.e. 75 mm total. Performance has been slightly less than adequate and some repairs have been required. An extra lift would have improved the pavement performance.

Contract 78-23 on Hwy. 17, Sturgeon Falls to Laronde Creek used a similar treatment to the above project. The special provision may be found in Appendix D. A greater depth of hot mix was used and performance has been very good to date.

On Contract 81-203 on Hwy. 17, Warren to Verner, a lack of base material was noted when the existing pavement was picked up. An on-site decision was made to use 75 mm of crushed R.B.M. under the new pavement width. Surplus R.B.M. was also used 100 % on portions of the shoulders.

On Contract 82-211 on Hwy. 64, the existing mulch pavement was pulverized full depth in-place and also removed full depth in some areas. The special provisions may be found in Appendix D. The removed material was crushed, stockpiled and brought back as granular base under the new pavement width in some locations. Surplus was used 100 % on shoulders. The construction report noted that additional water was required in order to work the pulverized in-place material.

Some contracts are planned during 1989 using the pulverizing technique.

Direct use on shoulders:

On Contracts 81-200 and 86-224 in the Sudbury District, processed bituminous pavement surplus to the recycling needs was placed 100 % on the

shoulders. The special provision for Contract 86-224 (Sudbury southwest bypass from Hwy. 17 to Hwy. 69) is included in Appendix D. A report from maintenance staff indicates that they were very satisfied with performance. They noted that:

- a) It remains compacted after grading/shaping. However, in some instances a difference in elevation between the pavement and the shoulder occurs due to the shoulder compacting more than anticipated. This has to be patched with cold mix.
- b) It seldom requires grading - areas occasionally get torn up by tractors or cruisers.
- c) There are few dropoffs and washouts.

Contract 81-203 on Hwy. 17, Warren to Verner and 82-211 on Hwy. 64 also used 100 % R.B.M. on the shoulders. Performance appears to be good to date. One anticipated problem is that of reshaping the shoulder when required. Since the bituminous material sets up to an extremely hard consistency, it may be necessary to rip or re-pulverize the shoulder.

4.2.2 Northwestern Region:

Almost all recycled paving contracts since 1983 have used some surplus R.B.M blended with Granular A. The intent was to have little, if any, surplus bituminous material at the end of each job.

Processing:

The old pavement is picked up full depth, taken off-site and crushed, blended with a standard Granular A and stockpiled. It is then trucked back to the jobsite to be used as a substitute for standard Granular A. Contract 83-225 called for the surplus pavement to be used 100 % as granular A. Fine grading the surface was difficult. Contract 88-223 called for the use of 5,500 tonnes of surplus reclaimed asphalt pavement as a component of the overall amount of Granular A on the project (52,176 tonnes). The special provision covering this item is included in Appendix D. The special provision called for the reclaimed material and Granular A to be stockpiled and blended from separate bins. In actual fact, the stockpile of blended material was constructed using the layer method. In this method, layers of material are placed into the stockpile such that a ratio of 60 % Granular A to 40 % R.B.M. is obtained, i.e. 1 m of granular and 600 mm of R.B.M. Problems occur with this technique if the pile gets too high or is left too long, when the

bituminous material sets up hard again. Figure 2 shows a typical gradation for the crushed R.B.M., and it is coarser than the Granular A envelope for all material finer than the 6.7 mm sieve. It has in the order of 1-2 % passing the 75 um sieve. Figure 3 shows a typical operation for placing the blended material on the shoulder using a shoulder spreader. This was on Contract 88-208, Hwy. 17.

Pulverizing:

One contract (76-06) was carried out at Terrace Bay in 1976 using this technique. A small pulverizing machine was used (approximately 2 metre width) with the intention of only pulverizing the pavement. However, it was almost impossible to operate without including some granular. The final blend was about 65/35 bituminous material to A. The grade set-up very hard and was then paved with an HL 2 levelling course followed by an HL 4 surface course. Performance to date has been good but some pavement distress is beginning to show now after 13 years of service.

Contract 88-201 on Hwy. 631 had the existing surface treatment scarified, then 100 mm of additional granular A was placed over this. Prior to paving, the surface was scarified again, and this had the tendency to mix some of the surface treatment material with the A, in effect creating a mixed in place product. However, some larger chunks of the surface treatment were pulled to the surface.

Contract 89-350 on Hwy. 519 was called in 1989 to use the pulverizing method.

4.2.3 Southwestern Region:

Pulverizing:

One project was carried out under Contract 88-61 on Highway 73, from the Elgin/Middlesex Boundary Northerly to Middlesex Road 29 (9.3 km). The existing pavement was to be pulverized with the underlying granular to pass the 37.5 mm sieve. A special provision covering this item is included in Appendix D. The existing pavement was 150 mm thick and this was too thick for the pulverizer. A cold-planing machine was used ahead of the pulverizer to remove approximately 75 mm of the pavement. It was noted in the Project Construction Report that the pulverized material was graded and compacted to the required roadway elevation, with any excess being left on the shoulder. The contractor was then advised to incorporate this excess material into the grade. This made it difficult to maintain correct grade elevations, since the depth of

surplus material on the shoulders was variable. Had the processing been carried out full-width from the start, this problem would have been avoided.

4.2.4 Central Region:

Pulverizing:

Over a section of Highway 54 at Regional Road 22 southeast of Hamilton, the existing pavement (60 mm thickness) was pulverized with the underlying granular under WP 78-79-05. The depth of pulverizing was designed to obtain a 40 % blend of bituminous material with the underlying granular base. Figure 16 shows the gradation of the blended material, which is almost all within the granular A envelope. Figure 17 shows the results of compaction tests on a standard Granular A and the blended material. The blended material has a lower density than the standard granular. This is due to the fact that asphalt cement has a lower Relative Density (1.04) than granular (approx. 2.65), which would tend to lower the bulk density of the blended material. Also, the optimum moisture content is higher, due to the fact that the gradation is somewhat finer than a standard Granular A.

The California bearing ratio of the mixed material was 43.3 %, tested immediately after compaction. This increased to a value of 134 % after 13 days aging in the laboratory at ambient temperature. This value compares favourably with the bearing ratio of a standard Granular A, which should be in the range of 100 to 150 %. The permeability of the mixed material was 1.39×10^{-3} cm/sec, which compares with values for standard Granular A which typically range from 10^{-3} to 10^{-4} cm/sec.

A project was also carried out on Highway 503 under Contract 88-47 from 0.6 km west of Hwy. 35 (Norland) easterly for 6.0 km. The existing asphalt pavement (80 mm average thickness) was blended with the underlying granular to a depth of 150 mm. A special provision is included in Appendix D.

A stable base resulted except where some Granular B was incorporated into the blended material.

Contract 88-77 on Highway 7A westerly from Hwy. 35 called for partial depth reclaiming of the asphalt pavement. The remaining pavement (50 mm average thickness) was pulverized and blended with the underlying granular to a depth of 150 mm. The special provision was similar to that used on Contract 88-47. However, a new special provision containing incentive clauses was included to promote the rapid placement of the new pavement over the prepared granular

grade. This would serve to reduce the time during which potholes could form in the blended material surface under the action of traffic.

Test data for the some of the above projects is summarized in Table 4.

Shoulder treatment:

A trial section was constructed in 1987 during paving operations on Highway 401 near Port Hope, in which milled pavement was discharged directly onto the shoulder and then mixed later with the underlying granular using a mechanical pulverizer. Testing indicated that a good product was obtained and performance appears to have been satisfactory to date. The shoulder was inspected in May of 1989 and found to be still in good order. Some granular has been added to maintain the elevation and crossfall.

The milled pavement was not tested for gradation. However, Figure 4 shows typical gradations of milled pavement from another contract. Figure 5 shows the milled material on the shoulder section. Figures 6 and 7 show the pulverizer at work. Figure 8 shows the shoulder after mixing, with no large fragments visible. Figure 9 shows normal shaping and compacting of the shoulder and Figure 10 shows a large fragment found in the blended material. Figure 11 shows gradations of the original shoulder material, which appears to be very fine, and the blended product, which is coarser.

Reclaimed asphalt pavement was also placed directly on sections of the shoulder of 401 under Contract 88-59. This contract called for milling of the driving lane and discharging of some of the milled material on to the excavated shoulder section. The shoulders were to be rolled with a steel-wheeled roller after placing of the asphalt material. A special provision covering this item is included in Appendix D.

The treated areas were inspected in May of 1989 and found to be generally in very good condition. Some minor problems were noted, as follows:

- a) A rut or drop-off was found at edge of pavement in some locations, as shown in Figure 12.
- b) Some of the R.B.M. was breaking up at the rut locations, as shown in Figure 13.
- c) Scrapes on the compacted R.B.M. were observed in some areas, as shown in Figure 14. This indicates that the blade of the grader may possibly remove chunks of material from the surface.
- d) One broken-up section was noted on the eastbound shoulder near Wilmot Creek which may be the result of close grading. See Figure 15.

4.2.5 Eastern Region:

Pulverizing:

Contract 88-04 was carried out on Hwy. 38, with the hot mix pavement being pulverized with the underlying granular. Gradations on material sampled at two stations are shown in Figure 18. Contracts 88-53 on Highway 515 and 88-41 on Highway 507 also called for pulverizing the pavement with the underlying granular. Figure 19 shows the pulverizing machine working one-third of the road width on Hwy. 515. Figure 20 shows the depth of cut taken down almost to the Granular B. Figure 21 shows the teeth on the pulverizing drum. Figure 22 shows the compacted surface after a few days of traffic. Figure 25 shows the surface of the compacted material on Hwy. 507 after a few days of traffic.

In the case of Hwy. 515, the pavement surfaces consisted of hot mix, mulch pavement and surface treatment. These surfaces varied in thickness and different pulverizing depths according to location of the various pavement types were addressed in a special provision. This is included in Appendix A. Figure 23 shows the gradation of the granular material from the source used on the original contract, together with three blended gradations.

The blend with surface treatment showed the finest gradation, followed by the mulch pavement. The blend with hot mix gave the best gradation of the three materials. Figure 24 shows results from compaction tests on the materials. All three blended materials produced compaction curves with lower densities and higher optimum moisture contents than those measured for granular A. This was due to the finer gradations of the blended materials.

C.B.R. tests on the three blended materials gave ratios that were very low compared with that of the granular A. However, these were tested immediately after compaction, i.e. without any aging time.

Permeability values varied from 1.7 to 3.4×10^{-4} cm/sec, comparable with values that would be expected for granular A.

These results are summarized in Table 5.

4.2.6 Discussion of Test Results:

(a) Gradation

Gradation testing shows that a bituminous pavement picked up and crushed off-site produces a slightly coarser gradation than that produced by milling the pavement. If crushed material is mixed with a standard granular A, it will produce a gradation on the coarse side of the A envelope. Mixing with

milled material produces a gradation which is finer. When the bituminous pavement is pulverized in-place, the gradation of the final product appears to depend on the quality and type of the original pavement. Pulverized hot mix will produce a coarser gradation than pulverized surface treatment. The gradation of the shoulder material on the Central Region trial was very fine. This may be due to the application of relatively large amounts of winter sand, which migrate onto the shoulder and become blended with existing shoulder granular. However, the gradation of the shoulder and milled pavement blend is largely within the granular A envelope (Figure 11).

None of the gradation tests carried out indicated that large amounts of fines were produced during any of the blending techniques used. Even the worst case material - surface treatment pavement pulverized in place with granular had less than 8 % passing the 75 um sieve (Figure 24).

(b) Compaction

Compaction testing indicates that the blended bituminous/granular mixtures produce lower maximum densities and higher optimum moisture contents than standard Granular materials. The lower density is due to the fact that asphalt cement has a lower relative density than stone. The increase in optimum moisture content is due to the fact that gradations of the blended materials are generally finer than the average granular gradations, particularly for those from pulverizing techniques.

(c) Strength

California bearing ratio tests indicated quite low values for the blended materials when compared with normal granular A. However, these were tested immediately after compaction, i.e. without any aging time. Tests were carried out to determine the effect of aging time on C.B.R. values (see Section 6.7).

(d) Permeability

Permeability tests carried out on the C.B.R. specimens indicate that the blended materials have permeability values comparable with Granular A and should therefore have drainage characteristics similar to Granular A.

4.2.7. Discussion of Field Data:

(a) Crushing and Stockpiling

When the recovered bituminous pavement has been crushed off-site and stockpiled, the material tends to harden or re-cement itself together and it is very difficult to handle. It should be mixed with granular as soon as possible after crushing to avoid this problem. On warm days, the crusher jaws

become coated with bituminous material and tend to lose their effectiveness. Crushing is more efficient if the temperature is lower, early or late in the day. One method adopted for building stock-piles of blended material is to layer the recovered bituminous pavement and granular in varying thicknesses representing a 40 % to 60 % mix. There are some difficulties with this technique. The bituminous material tends to set-up within the stockpile, and is then not readily mixed with the granular by front-end loader or hopper. Large chunks of recemented material can appear on the grade and have to be removed.

(b) Compaction

On the road, the blended material appears to compact better if little or no water is used. Where there are transitions to standard granular grade, the blended material layer reduces in thickness. These areas tend to ravel off very quickly under traffic action. If standard granular for padding is placed over a blended material after traffic has been allowed on it, the traffic action will quickly cause a great deal of float. Apparently the standard granular does not bond readily with the underlying blended material.

(c) Pulverizing in place

During the mixed-in-place process, the spacing of the teeth on the drum of the pulverizer and the speed of the pulverizer are important. If the teeth are spaced too wide, it is difficult to reduce the bituminous pavement portion of the blended product to pass 26.5 mm size. This also occurs if the machine is moving too quickly. The appearance of the processed material is finer if the pavement is cold and coarser if the pavement is hot. This has not been confirmed by testing. The depth of processing is outlined in the special provision and this must be monitored closely. Problems encountered include cutting too deep (into underlying Granular B) or too shallow (increasing the percentage of R.B.M.). Oversize pieces may occur in the product, particularly if there are small sections of partially paved shoulder present on the road.

(d) Milled Pavement on Shoulders

There are a number of problems with discharging of milled pavement material directly onto the shoulder. Firstly, measurement for payment is difficult, as the material cannot be weighed. The milled thickness can vary depending on the pavement condition. Secondly, the shoulder section has to be prepared to the correct crossfall before the milled material is placed,

otherwise an uneven thickness of milled material will result. This would create problems with the blend ratio if the material is to be mixed into the underlying shoulder granular at a later date. Thirdly, there is the problem of creating a shoulder elevation higher than the roadway elevation and producing a drainage problem. If the milled material is to be left on the shoulder at 100 %, measurement of compaction is very difficult. Proof rolling was used in Northern Region, with the vibratory roller omitted, as it tended to reduce the compaction effect.

(e) Fine Grading

It has been frequently noted that fine grading of the surface of a blended material prior to paving is very difficult, especially if the time elapsed between finishing the grade and paving is large. The grader also tends to pick out or pull up larger fragments. Potholes which may form are also a problem, as they cannot be filled with standard granular. The best solution is to pave as quickly as possible after compaction and early paving payment incentives may be used to promote this. However, a small pile of blended material should be saved to use for filling any potholes which may occur.

(f) Performance

A number of sections of road constructed with blended bituminous/granular in the base course were examined for problems and ride quality in Eastern Region in April and Northern Region in May of 1989. In general, the ride quality of all sections examined was very good and no major problems were noted or reported.

5. USE OF RECOVERED MATERIALS IN EARTH FILL

Portland cement concrete and bituminous pavement are designed to give a high level of performance during their working life. Aggregates of a high quality are therefore used in their construction. Even when these materials have been recovered, the quality of their aggregate content has not changed. From an economic point of view, they still represent a valuable resource and should be used in such a way as to realize maximum benefit. Use in recycled bituminous pavement or as a granular substitute achieves this. However, environmental concerns dictate that all recovered materials should be disposed of in such a way as to have little or no impact on the environment. If the amount of recovered material to be used on a contract in recycled pavement or as granular is less than the total recovered amount, then the surplus may be used in earth fill situations.

Some restrictions would apply to this use, as follows:

- a) Recovered bituminous pavement should not be used in situations where wells or natural water courses are situated close to the fill area. This is outlined in Special Provision 199F30 (November 1988).
- b) Since the recovered materials in these situations will probably not be crushed, SP199F30 states that such materials shall not be placed where they may interfere with future construction activities.
- c) Size and placement restrictions should apply in the same manner as for boulders and cobbles. An amendment to OPSS 206 is included in Appendix D.
- d) Additional attention to compaction will be required to ensure that no large voids are left in the fill which may lead to later problems with differential settlement.

6. PROPERTIES OF R.B.M. MIXTURES WITH GRANULAR

6.1 Laboratory Testing Program Outline

It was decided to carry out a laboratory testing program on bituminous material mixed with a standard Granular A to obtain the physical parameters of a material currently in use on Ministry contracts. The bituminous material used was a crushed product from Northwestern Region and the Granular A was from the Regan-Graham pit located near Toronto and sampled from a stockpile produced for a Ministry contract. The main aim of the program was to compare the parameters of mixtures containing varying percentages of bituminous material. This was to determine the most suitable percentage of R.B.M. to include in granular material on a routine basis on Ministry contracts.

6.2 Program details

The testing consisted of gradation, compaction, California bearing ratio and permeability. The tests were carried out with following R.B.M. to granular ratios: 0, 20, 40, 60, 80 and 100 %. Compaction testing was done to establish the moisture content values for the C.B.R. testing.

6.3 Gradation

Figure 25 shows the gradation curves for the six materials. The crushed bituminous material was coarser than the granular A envelope and all of the blended gradations lie within the A envelope.

6.4 Compaction

Figure 26 shows the laboratory Proctor curves for dry density. As found with previous testing, the dry density decreased with the addition of bituminous material. It is interesting to note that the optimum moisture content is within a 0.5 % range for the samples tested, due to the fact that all the gradations are very similar, hence there is no appreciable fineness effect.

6.5 Permeability

Permeability testing was carried out on samples of the standard granular A, a blend ratio of 60 %, and the 100 % crushed and milled bituminous pavement. The value obtained for the Granular A was in the order of 10^{-4} cm/sec while the other values were in the order of 10^{-3} cm/sec. The 60 % blend and 100 % crushed and milled pavements have coarser gradations than the A, and the permeability values are in line with this.

Table 6 summarizes the data discussed above, together with C.B.R. bearing values.

6.6 California Bearing Ratio

The C.B.R. data was of primary interest, since the samples taken in the field from contracts had produced quite low values tested immediately after compaction. Figure 28 shows data from C.B.R. tests at varying percentages of R.B.M. The C.B.R. decreased from 129 % for the natural granular A to 11.7 % for an 80 % R.B.M. blend. The 100 % R.B.M. material gave a value of 13.1 %. Traditional design requirements using the C.B.R. method call for a value well over 80 % and preferably in excess of 100 % for a well-graded gravel base. It can be seen from the curve that the natural granular and the 20 % blend satisfy these requirements. However, at a 40 % blend (proposed for general use in Ministry construction) the C.B.R. is only 53 %. In addition to this, very low values had been obtained on material from Eastern Region contracts (average C.B.R. of 20 %). Material from the Highway 54 contract in Central Region had a C.B.R. of 43.3 % at an approximately 40 % blend ratio. However, all these C.B.R.'s were carried out immediately after the specimens had been compacted. Since these values were low, yet good performance had been obtained on roads using blended R.B.M. and Granular A, it was decided to age some test specimens at the various blend ratios for different time periods prior to subjecting the samples to C.B.R. testing. This data is summarized in Table 7 and plotted in Figure 29 for specimens left for 2, 6 and 14 days, compared with the original C.B.R. data for specimens tested immediately after compaction. C.B.R. values greater than 100 % were obtained for blend ratios up to 60 %. Figure 30 shows the strength gain with time for a blend ratio of 40 %.

All of these samples were left at laboratory ambient temperature for the aging period and underwent some moisture loss. This might be considered to approximate normal construction conditions. However, the effect of additional moisture was of concern, so some tests were repeated leaving the specimens in a wet environment for two and ten days and then soaking the specimens for four days in the water bath. The Granular A had a C.B.R. value of 149 % at 14 days, which is higher than the uncured value, i.e. 129 %. Specimens with 40 % R.B.M. had values of 44 % at 6 days and 55 % at ten days, which are virtually the same as the value obtained immediately after compaction (53 %). This is probably due to the fact that total immersion inhibited the tendency for the mixture to re-cement itself. Total immersion is severe and is unlikely to

occur in the field. Additional testing will be carried out to investigate the low soaked C.B.R. values on R.B.M./granular mixtures. Since the C.B.R. values obtained on the blended materials are low immediately after compaction and higher after they were left for any period of time, it is assumed that the strength gain is due partly to drying and partly to the asphalt cement from the crushed R.B.M. re-cementing the mixed material. The fact that fine grading is more difficult on a blended material than a standard granular during construction would support this.

However, it was considered that there may be some contributing effect from the granular material itself. A specimen of the granular A was prepared, left for 14 days and tested for C.B.R. It gave a bearing value greater than 300 %, compared to a value of 129 % for the specimen tested immediately after compaction. Since this large gain may be primarily due to drying, another specimen was prepared. After leaving this specimen in a wet environment, the C.B.R. value was 149.3 %, still higher than the value for the specimen tested immediately after compaction.

A granitic aggregate was obtained from the Muskoka area for testing. It was somewhat finer than a standard Granular A, having only 38.5 % retained on the 4.75 mm sieve. The C.B.R. tested after compaction was 63.6 %, about half the figure obtained for the Regan-Graham material. After a 14 day period in ambient temperature, the C.B.R. value increased to 152 %. This shows a similar trend to the Regan-Graham material, but of a lower order. After leaving another specimen in a wet environment for 13 days, the C.B.R. value was found to be 106 %. The fineness of the material is a contributing factor to the lower strength compared with the other aggregate tested, however, it appears that both aggregates exhibit some strength gain after compaction, possibly due to some kind of cementing action.

6.7 Effects of Fineness on Strength

It has been well documented that C.B.R. values tend to decrease as materials become finer. Since the gradations obtained from samples of milled or mixed-in-place materials tended to be on the fine side of the Granular A envelope, additional test specimens were prepared to check the strengths obtained. Duplicate series of samples were prepared, one using standard Granular A and one using a 40 % blend ratio of R.B.M. Each series had one sample at the lower limit of the A envelope and one at the upper limit. Two additional samples with 80 % and 100 % passing the 4.75 mm sieve were also prepared for each series.

These C.B.R. results are summarized in Table 8 and shown in graphical form in Figure 31. All specimens were tested immediately after compaction. It may be seen that the C.B.R. increases with the increase in coarse aggregate percentage, although the effect is not as marked for the blended material. The values for the blend would increase with drying.

6.8 Discussion of Results

The strength of the blended material is of primary importance, particularly if the material gains widespread use as a substitute for standard Granular A. Since the gradation of the material is difficult to control with the processes used, there is a likelihood that it will not always fall within the granular envelope. In fact, the results of the mixed-in-place projects in Eastern Region confirm this. So, it follows that another approach is needed. If the bearing strength of the blended materials is equal to or exceeds that of a standard Granular A, then it might be argued that the gradation does not have the importance required of standard granular material. However, since the C.B.R. does decrease with increasing fineness, there must be a limiting value on the gradation. This should be set at 75 % to allow for mixing-in-place of surface treated pavement. This produced the finest gradation of any materials tested, and yet has given adequate field performance to date. The amount of R.B.M. allowed as a percentage of the final product is also important. Northern Region experience indicates that 100 % R.B.M. used as a base material does not appear to adversely affect pavement performance. However, the assumption that R.B.M. contributes additional strength to the pavement structure should not be used as a rationale for reducing the depth of granular or the pavement thickness. From the laboratory testing carried out on blended materials, bearing values equivalent to a standard Granular A have been obtained up to a 60 % ratio. However, the allowable percentage has been fixed at 40 % for the Trial Contracts in 1990 and 30 % for all Ministry contracts in 1989. The reason for the 30 % figure is that the Contractor may elect to use R.B.M. from non Ministry contracts consisting of lower quality pavement.

There is also a possibility that the type of granular material already in place or available for mixing with crushed R.B.M. will be a factor, since the testing indicates that an aggregate increases in bearing value with aging. This may be seen from the results recorded in Table 7.

Permeability of the blended materials does not appear to be a problem.

7. SPECIAL PROVISIONS

Special Provisions have been issued and may be found in Appendix D. There are three groups of S.P.'s in addition to those already used on contracts in the various regions. They are as follows:

i) Trial Contracts - These have been designed to give the Contractor the option as to where he elects to use recovered concrete or bituminous materials on specific contracts in 1990.

Use of the material in embankments is covered by a standard special to modify OPSS 206 (Grading).

Use of recovered bituminous pavement in granular or on shoulders is covered by a standard special to modify OPSS 314 (Granular).

It was decided to modify OPSS 314 rather than OPSS 1010 due to the fact that physical tests used to qualify granular materials in OPSS 1010 are not applicable to the blended products.

The percentage of recovered bituminous pavement allowed to be mixed with granular is set at a maximum of 40 %.

ii) Regular Contracts - These were designed to enable material surplus to recycling requirements to be utilized to the fullest extent during the 1989 construction season. OPSS 206 and OPSS 314 were modified as outlined in (i) above, except that the percentage of recovered bituminous pavement is set at a maximum of 30 %. This is to allow for the fact that the Contractor may elect to use bituminous material from non-Ministry contracts which could contain lower quality pavement than allowed on Ministry contracts.

The following additional modifications were made:

Crushed Portland cement concrete may be used as Granular A, B and M. A Special Provision to amend OPSS 1010 includes reclaimed Portland cement concrete as an acceptable alternative to granular products. Gradations must conform to existing standards.

iii) Geotechnical Options - These are designed to allow for activities which will be governed by the Geotechnical Section concerned. These consist of in-place processing of bituminous pavement and placing R.B.M. on shoulders.

8. CONCLUSIONS

8.1 Recovered Portland Cement Concrete

Recovered Portland cement concrete material meeting the requirements of the specification may be used as Granular A, B and M on Ministry contracts. The small quantities produced are mostly used by municipalities.

8.2 Recovered Bituminous Pavement

Evaluation of projects carried out using R.B.M. as a replacement or substitute for granular show that these blended materials perform most satisfactorily, and appear to give slightly superior performance when compared to standard granular material - probably a function of hot mix aggregates having higher quality requirements combined with the binding effect of the asphalt.

8.3 Laboratory Parameters

Laboratory data indicates that the strength of the blended product will be lower than that of a standard granular, but will increase with time. However, strengths are low in soaked conditions, and more investigation of this problem is required. The permeability is of the same order as a compacted granular, and in some instances is higher. This indicates that the blended material will drain at least as well as the standard granular.

8.4 Construction

Certain construction problems have been noted, as follows:

- a) Good stockpiling techniques must be used. It is preferable to mix the R.B.M. with granular prior to stockpiling. The layer method can lead to problems with large uncombined chunks of R.B.M. appearing on grade.
- b) Fine grading the compacted surface is a problem. Paving should be carried out as soon as possible after compaction. Incentives in the special provisions may be used to encourage paving quickly.
- c) Good pulverizing techniques must be used. The speed of the machine and spacing of cutting teeth are important factors in keeping the gradation of the resulting blended material within proper limits.
- d) Some problems may occur with 100 % R.B.M. on shoulders. Fine grading and repair of damage to the shoulder is difficult. Additional material does not appear to bond with the existing shoulder.

8.5 Field Control

There is a need for field control techniques to be established to check on blend ratios, gradation and compaction.

9. RECOMMENDATIONS

- 9.1 *The Ministry should continue to use Recovered Bituminous Material (R.B.M.) as a substitute for granular materials. Both crushed off site and mixed in place techniques are acceptable.*
- 9.2 *Methods of control for compaction, gradation and blend ratio on granular and R.B.M. mixtures should be developed and implemented.*
- 9.3 *Since fine grading of surfaces with greater than 50 % R.B.M. may be difficult, incentive special provisions to encourage rapid paving in these cases should be implemented.*
- 9.4 *A test section should be constructed in 1990. The base should have varying percentages of R.B.M. and a control using standard Granular A. Suggested R.B.M. percentages are 50, 75 and 100 per cent. The whole project should be monitored closely during construction to document problems which may occur. In addition, the pavement should be subjected to long term monitoring for performance.*
- 9.5 *Additional testing should be undertaken to investigate the soaked or wet strength of mixtures of various percentages of R.B.M. and standard granular material. Resilient modulus or California bearing ratio testing could be used for strength measurements.*
- 9.6 *Contracts constructed in 1989 and 1990 should use the recommended 30 % maximum R.B.M. content. Trial contracts for 1990 construction should use the recommended 40 % maximum R.B.M. content. The maximum R.B.M. content for future work should be assessed after the field and laboratory studies noted above.*

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The authors acknowledge the work of Zoltan Katona on the use of recovered concrete materials.

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APPENDIX A

REPORT ON EASTERN REGION CONTRACTS

BY R.J. SCOTT

REPORT ON EASTERN REGION CONTRACTS

by R.J. Scott

Contract 88-04 - Highway 38.

This Contract was 11.6 km in length, from Tichborne N. limits northerly to 4.2 km south of Highway 7. The pavement structure consisted of 40 mm HL 4 over 150 mm of Granular A over 150-450 mm of Granular C (Contract 69-510).

A Pavement Condition Report (P.C.R.) carried out in 1986 gave a condition rating of 58 with a comfortable ride and a few rough sections noted. The distresses consisted mainly of transverse cracks, longitudinal cracks, alligating and rutting. Some patching had been carried out. The recommendation was to remove the pavement and place 50 mm of Recycled Hot Mix over granular padding as required.

After the Contract was awarded, the Ministry approached the Contractor with respect to introducing a new item 'Reclaim and Process Hot Mix Pavement/Granular Base Course' and eliminating 'Removal of Asphalt Pavement'. This was agreed to and a Special Provision was drafted by the Geotechnical Section. It called for the processed material to pass the 37.5 mm sieve.

The agreement by the Contractor to reclaim the pavement and not claim for a reduction in granular quantities resulted in a saving to the Ministry of \$43,000. It was suggested in the Project Construction Report that the savings would have been higher had the contract originally been set up with the changed item, rather than negotiated after award.

There were no major problems noted in the Project Construction Report.

Contract 88-53 - Highway 515.

This contract was 12 km long, from Hwy. 62 southerly to Hwy. 514, excluding 1.4 km at Palmer Rapids. The pavement structure consisted of a minimum of 60 mm of surface treatment or mulch pavement (1977). A P.C.R. carried out in 1987 to Palmer Rapids gave a condition rating of 60 and noted rippling, wheel track rutting and some cracking. The section from Palmer Rapids to Hwy. 514 consisted of 40-50 mm HL 4 over 150 mm Granular A and 150-225 mm Granular C. This had a condition rating of 68 with similar faults as noted for Contract 88-04.

The contract called for reclaiming the existing riding surface and granular road bed to a depth of 100 mm for surface treatment and 200 mm for hot mix and mulch pavements in place. The resurfacing consisted of 50 mm of HL 4 hot mix.

There were no major problems noted in the Project Construction Report.

Contract 88-41 - Highway 507.

The length of this contract was 37.9 km, and it had been originally reconstructed under 5 separate contracts and various day labour projects. After completion of these rehabilitation projects, Contract 88-41 was tendered in order to provide a continuous and uniform surface treated roadway. Included in the project were repairs to 13.7 km of flushed surface treatment by reclaiming, processing and incorporating into the existing granular. Pavement condition reports in 1987 gave condition ratings from 68 to 85 over the various sections with some distress noted in the older section (4.2 km south from Hwy. 503)

The Project Construction Report included the following problems and recommendations.

1. There should have been a typical section to detail the 'Reclaim Mulch Pavement' item. Contract Management questioned the design quantities calculated versus the special provision requirements. The design quantities for reclaiming were calculated on the same area as the surface treatment item while the special provision appeared to indicate only the actual existing pavement width. After discussion with the Construction Supervisor, a letter was issued to the contractor to reclaim as per the quantities and locations indicated in the breakdown sheets. A typical section would have clarified the width desired by the designer.
2. The contractor had problems in the reclaiming areas preparing and maintaining the granular grade for surface treatment. There was a time lapse of 10 days between the reclaiming and granular operations (add 50 mm Granular M to correct crossfall and superelevation). This resulted in the grade hardening up so much that it almost had to be pulverized again.
3. The item for 'Reclaiming Mulch Pavement' was not a PQP item. If it had been PQP, it would have eliminated a great deal of work in calculating the final quantity.

4. A special provision should be included in future operations of this nature to coordinate the reclaiming and granular (or paving) operations so that material will be thoroughly mixed and possibly easier to reshape for the final paving operation.

Contract 88-74 - Highway 62

This contract had a length of 15.8 km from Hwy. 60 northerly to 0.5 km south of Bonnechere (excluding a 2.6 km section at Round Lake Centre). It was previously reconstructed under Contract 64-47 and various Day Labour projects. The contract called for hot mix resurfacing (25 mm HL 2 and 40 mm HL 4 for the southern 7.2 km and 50 mm HL 4 for the remainder). Under contract item 'Restoring Roadway Surfaces', the contractor elected to pulverize the existing surface and incorporate it into the underlying granular. This item was utilized to restore horizontal alignment to superelevated curves. Pavement Condition Reports carried out in 1987 gave a condition rating of 55 for the whole section with numerous distresses noted, including an observation that the ride was uncomfortable.

The Project Construction Report recommended that if Granular A or M is to be added, it should be placed at the time of pulverizing, as the pulverized base has a tendency to set up, making final grading more difficult.

Special Provisions for Contracts 88-04, 88-53 and 88-41 are appended.

Special Provision for Contract 88-04.

RECLAIM AND PROCESS HOT MIX PAVEMENT/GRANULAR BASE COURSE - Item No.

Scope

This special provision covers the work of reclaiming existing hot mix pavement and granular to a depth of 150 mm in place and compacting the processed materials as base course under the new pavement on the road as indicated in the contract drawings.

The thickness of the existing hot mix pavement varies from 33 mm to 100 mm with an average of 45 mm.

Construction

While reclaiming the hot mix pavement, the Contractor shall ensure that the pavement and the granular base course are thoroughly mixed to a depth of 150 mm. It shall be sufficiently processed so that all of the mixed material passes a 37.5 mm sieve size.

The surface of the processed material shall be bladed, shaped, compacted and if necessary, Granular A shall be added to produce the required cross-section of the surface in accordance with OPSS 301. This material shall be compacted to a minimum 100% maximum density as determined by the current Ministry Standard Moisture Density Test. The Field Density shall be determined by the nuclear method.

The reclaiming and processing, including compaction, shall be worked to the same station for both lanes prior to closing down operations each day.

Measurement for Payment

Measurement and basis of payment for water and calcium for compaction and dust control shall be as per OPSS 501.

Measurement for reclaimed hot mix pavement shall be in square metres, measured in place in a horizontal plane.

Materials added and incorporated into the roadway surface during restoring operations shall be measured as specified in the specification for the type of material so added.

Basis of Payment

Payment at the contract price for the above item shall be full compensation for all labour, equipment and material required in the process to reduce the hot mix material to the required size and mix with the granular base course. It shall also include blading, shaping and compacting the processed hot mix pavement/granular base course.

Payment for materials added will be made as specified in the specification for the material so added.

Special Provision for Contract 88-53.

RECLAIM AND PROCESS EXISTING PAVEMENT/GRANULAR BASE COURSE - Item No.

Scope

This special provision covers the work of reclaiming existing pavement and granular in place and compacting the processed materials as base course.

Where the existing pavement consists of surface treatment only, the existing pavement and granular base shall be reclaimed and processed to a depth of 100 mm.

Where the existing pavement consists of hot mix or mulch in addition to the surface treatment, the existing pavement and granular base shall be reclaimed and processed to a depth of 200 mm.

The following are the locations and average thickness of the hot mix and mulch pavement:

<u>Station to Station</u>	<u>Township</u>	<u>Type</u>	<u>Average Thickness</u>
1. 10+004 - 10+040	Radcliffe	Hot Mix	60 mm
-			
12. 10+825 - 13+258	Raglan	Mulch	110 mm

Construction

While reclaiming the existing pavement, the Contractor shall ensure that the existing pavement and granular base course are thoroughly mixed to the specified depth. It shall be sufficiently processed so that all of the mixed material passes a 37.5 mm sieve.

The surface of the processed material shall be bladed, shaped and compacted in accordance with OPSS 301 and if necessary, Granular A should be added to produce the required cross-section of the surface. This material shall be compacted to a minimum 100 % maximum density as determined by the current Ministry Standard Moisture Density Test and to the requirement of OPSS 501.

The reclaiming and processing, including compaction, shall be worked to the same station prior to closing down operations each day.

Measurement for Payment

Measurement and basis of payment for water and calcium for compaction and dust control shall be as per OPSS 501.

Measurement for reclaimed existing pavement shall be in square metres, measured in place in a horizontal plane.

Materials added and incorporated into the roadway surface during restoring operations shall be measured as specified in the specification for the type of material so added.

Basis of Payment

Payment at the contract price for the above item shall be full compensation for all labour, equipment and material required in the process to reduce the existing pavement to the required size and mix with the granular base course. It shall also include blading, shaping and compacting the processed pavement/granular base course.

Payment for materials added will be made as specified in the specification for the material so added.

Special Provision for Contract 88-41.

RECLAIM MULCH PAVEMENT - FULL DEPTH - Item No.

Scope

This special provision covers the work of reclaiming existing pavement and mixing the reclaimed pavement with the underlying granular to a depth of 100 mm average in place and compacting the processed materials as granular base course under the pavement on the road.

Construction

While reclaiming the pavement, the Contractor shall ensure that the processed pavement and the existing granular base course are thoroughly mixed to a depth of 100 mm average. It shall be sufficiently processed so that all of the mixed material passes a 37.5 mm sieve size.

The surface of the processed material shall be bladed, shaped, and incorporated with Granular M and compacted to produce the required cross-section of the surface in accordance with OPSS 301 and OPSS 501.

The reclaiming and processing shall be worked to the full width of the existing paved surfaces and the entire roadway shall be processed to the same station prior to closing down operations each day.

Measurement for Payment

Measurement and basis of payment for water and calcium for compaction and dust control shall be as per OPSS 501.

Measurement for Reclaim Mulch Pavement - Full Depth shall be in square metres, measured in place in a horizontal plane.

Basis of Payment

Payment at the contract price for the above tender item shall be full compensation for all labour, equipment and material required in the process to reduce the existing pavement material to the required size and mix with the existing granular base course. It shall also include blading, shaping and compacting the processed pavement/granular base course.

APPENDIX B

TABLES



Test	Port Authority Report	Hicksville Plant Report
Los Angeles Abrasion (%)	37.1	36.5
Magnesium Soundness (%)	3.3	3.5
C.B.R. (%)	148.0	148.0
Maximum Dry Density (pcf)	128.0	128.8

Table 1. Recycled Crushed Concrete Data (New York).

Test	82-9032 Gran. A	82-9033 Gran. A	83-9574 Gran. B
Los Angeles Abrasion (%)	-	-	32.1
Magnesium Soundness (%)	3.0	4.0	-
Absorption (%)	4.61	4.64	4.33
Bulk Relative Density	2.36	2.36	2.36
C.B.R. (immediate)	82.70	-	86.60
(cured 7 days)	94.40	90.30	-
Permeability (cm/sec)	-	1.9×10^{-4}	-
Swell after 7 days	-	-	0

Table 2. Recycled Crushed Concrete Data (M.T.O.)

REGION	YEAR	CONT. #	HWY.	METHOD	R.B.M. USE
Northern	1971	Test Site	11	Pulverized	100 % Base
	1976	76 - 03	11	Crushed	100 % Base
	1978	78 - 23	17	Crushed	100 % Base
	1981	81 - 200		Milled	100 % Shoulders
	1981	81 - 203	17	Crushed	100 % Base
	1982	82 - 211	64	Pulverized	100 % Base & Shoulders
	1986	86 - 224	17/69	Crushed Milled	100 % Shoulders
Northwestern	1976	76 - 06	17	Pulverized	< 100 % Base
	1983	83 - 225	(17)	Crushed	100 % Base
	1988	88 - 201	631	Scarified	30% +/- in Base
	1988	88 - 208	17	Crushed	40 % Shoulders
	1988	88 - 223	17	Milled & Crushed	40 % Base
Southwestern	1988	88 - 61	73	Pulverized	40 % Full Width
Central	1987	Exp'mental	401	Milled & Pulverized	40 % Shoulders
	1988	88 - 59	401	Milled	100 % Shoulders
	1988	78-79-05	54	Pulverized	40 % Base
	1988	88 - 47	503	Pulverized	40 % Base
Eastern	1988	88 - 04	38	Pulverized	40 % Base
	1988	88 - 41	507	Pulverized	40 % Base
	1988	88 - 53	515	Pulverized (Hot Mix) (Mulch) (S. T'ment)	40 % Base

Table 3. Regional Experience With R.B.M.

	Aggregate %		C.B.R. % (0.2" Pen)	Permeability cm/sec.
	Coarse	Fine		
Hwy. 401 Shoulder Granular	36.0	64.0	-	-
Hwy. 401 Shoulder Granular + R.B.M.	46.0	54.0	-	-
Hwy. 54 A + R.B.M. (Uncured)	47.7	52.3	43.3	1.39×10^{-3}
Hwy. 54 Material (14 Day Cure)	47.7	52.3	134.0	-

Table 4. Central Region R.B.M. Test Results.

	Aggregate %		C.B.R. % (0.2" Pen) *	Permeability cm/sec.
	Coarse	Fine		
Granular 'A' from Crown Pit	46.5	53.5	166.0	5.8×10^{-4}
Hot Mix Pavement + Granular 'A'	38.9	61.1	17.7	3.4×10^{-4}
Mulch Pavement + Granular 'A'	29.9	70.1	24.3	1.7×10^{-4}
Surface Treatment + Granular 'A'	28.2	71.8	20.2	2.2×10^{-4}

* Tested immediately after compaction, i.e. no curing time

Table 5. Eastern Region R.B.M. Test Results.
Contract 88-53, Highway 515.

Granular and % R.B.M. mixed	Aggregate %		C.B.R. % (0.2" Pen)	Permeability cm/sec.
	Coarse	Fine		
Granular A	47.8	52.2	129.0	1.04×10^{-4}
A + 20 % mix	51.5	48.5	95.3	-
A + 40 % mix	57.6	42.4	53.0	-
A + 60 % mix	61.2	38.8	26.7	1.04×10^{-3}
A + 80 % mix	63.9	36.1	11.7	-
100 % RBM (Crushed)	67.2	32.8	13.1	1.35×10^{-3}
100 % RBM (Milled)	60.0	40.0	-	7.57×10^{-3}

Table 6. Laboratory Test Results for
various R.B.M./Granular Blends.

	C.B.R. Values at days of Aging					
	0	2	6		14	
	O.M.C.	'Dry'	'Dry'	'Wet'	'Dry'	'Wet'
Granular A	129.0	-	142.6	75.3	306.0	149.3
20 % R.B.M.	95.3	-	-	-	200.0	-
40 % R.B.M.	53.0	84.3	168.0	44.0	220.0	55.0
60 % R.B.M.	26.7	-	-	-	116.0	-
80 % R.B.M.	11.7	-	-	-	46.7	-

Table 7. Effects of Aging
on C.B.R. Strength.

	Aggregate %		C.B.R. %	
	Coarse	Fine	No R.B.M.	40 % R.B.M.
Granular A Spec. Lower Limit	65	35	> 183.0	38.0
Granular A Spec. Upper Limit	45	55	> 114.0	22.8
Gradation above A Upper Limit	20	80	49.3	14.7
100 % Passing Passing 4.75 mm	0	100	36.0	9.7

Table 8. Fineness Effect on Strength
of Unaged Samples.

APPENDIX C

FIGURES

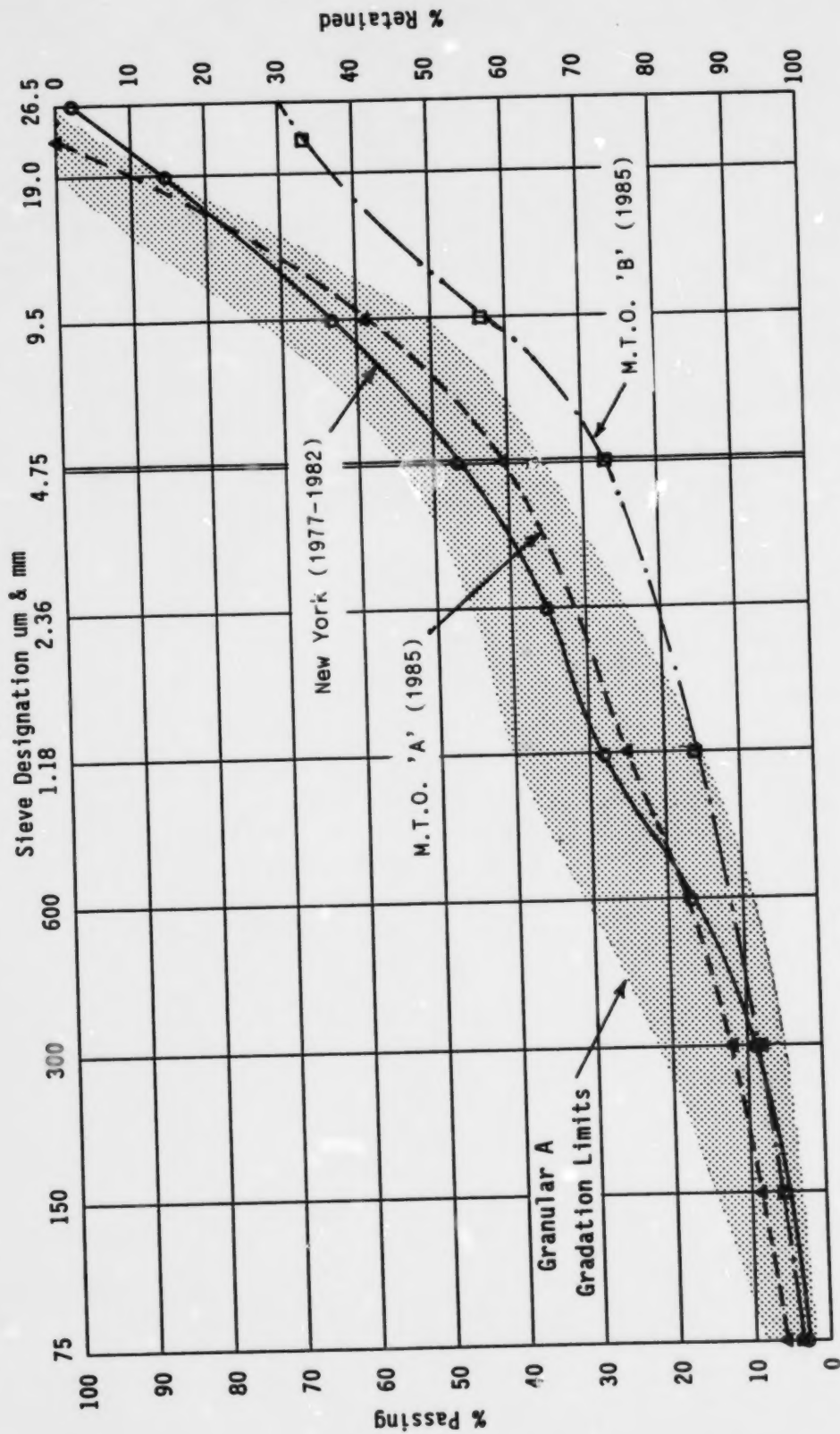


Figure 1. Recycled Crushed Concrete Materials.

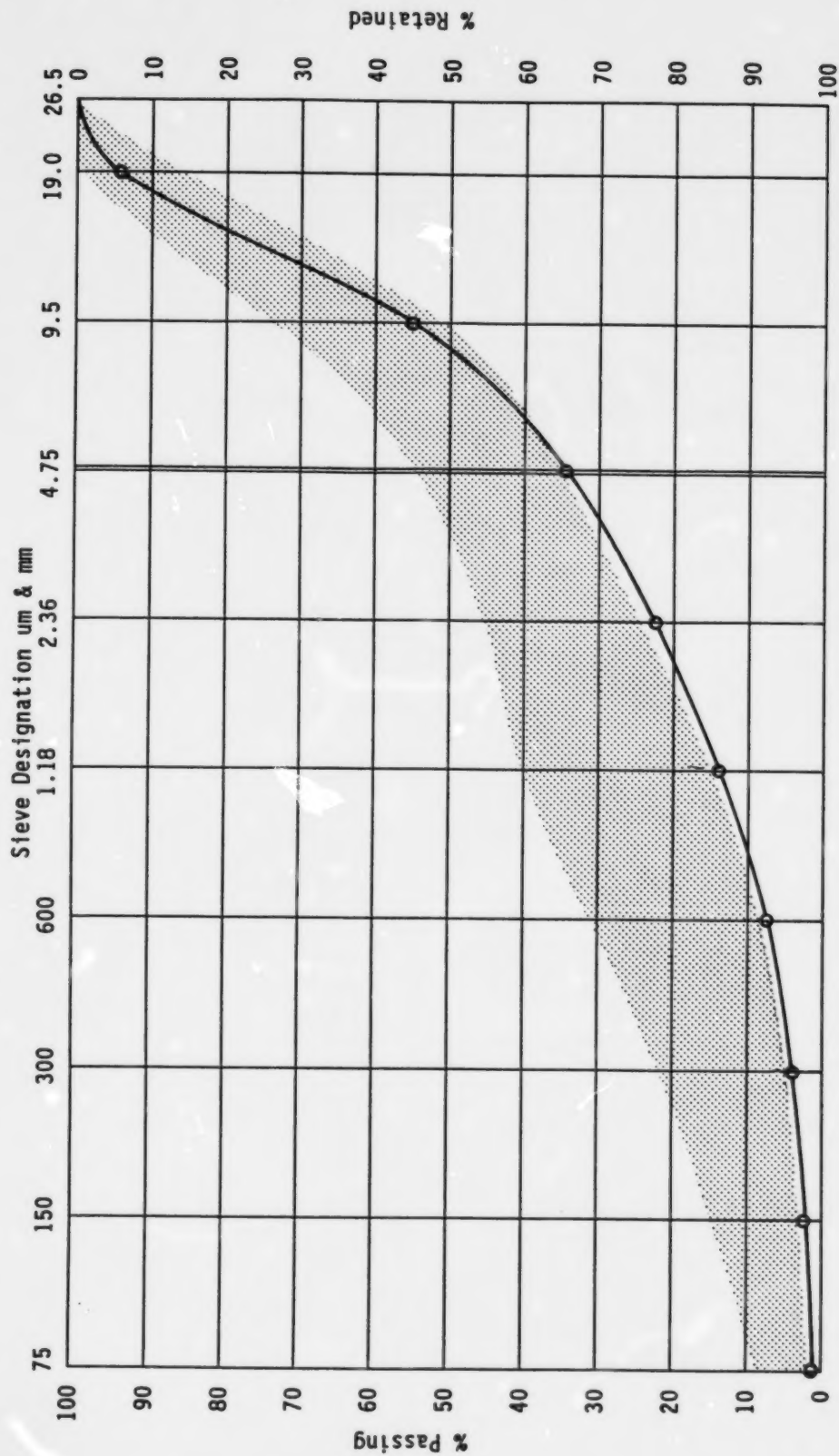


Figure 2. Crushed Hot Mix Pavement as R.B.M. (N.W. Region).



Figure 3. Placing Blended Material on a Shoulder using a Spreader. 88-208. Hwy. 17, N.W. Region.

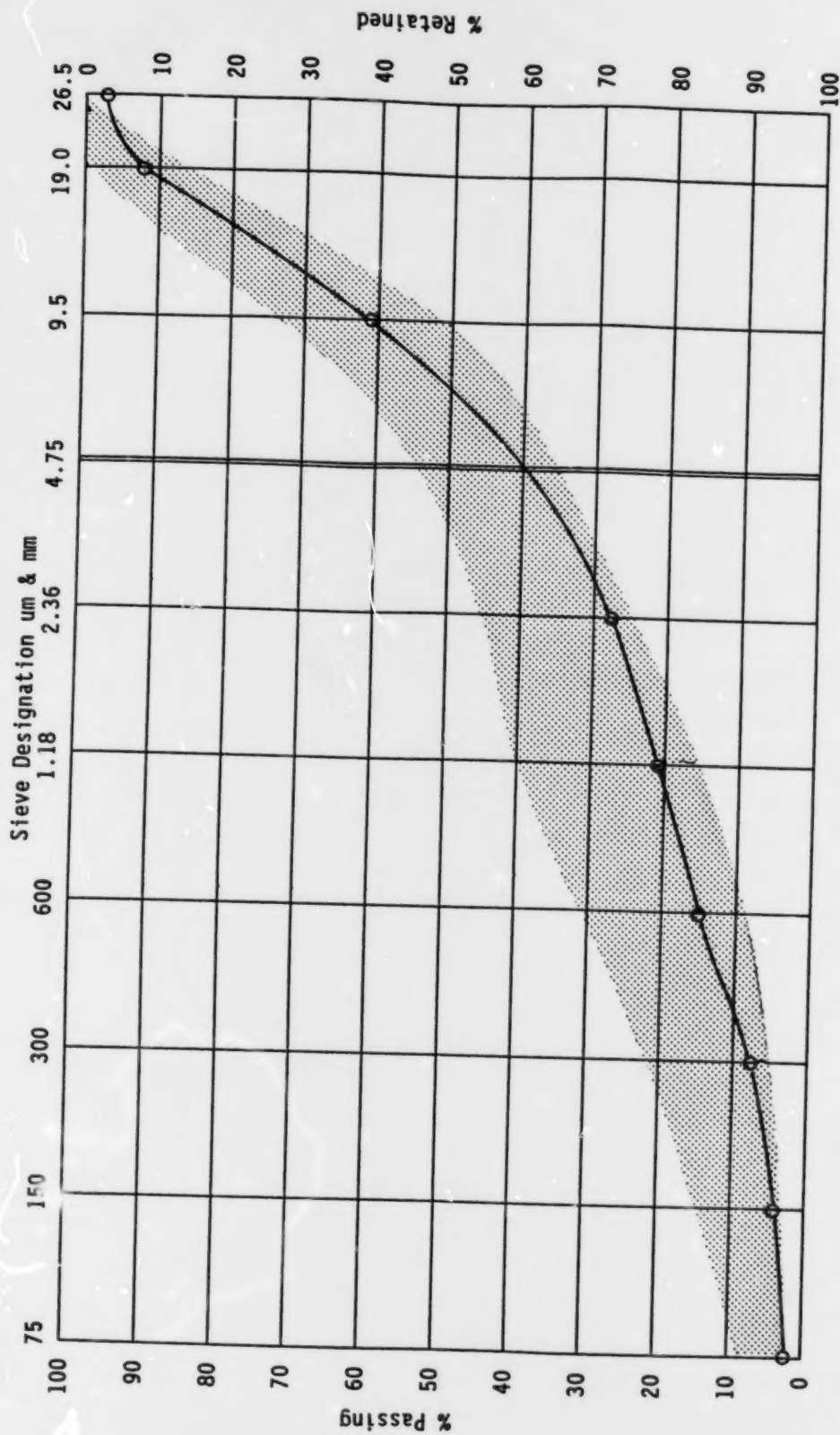


Figure 4. Milled Hot Mix Pavement as R.B.M. (Typical)

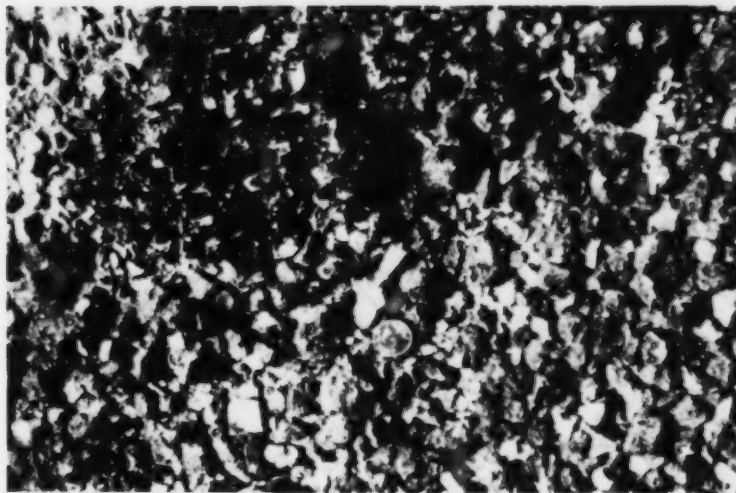


Figure 5. Milled R.B.M. on the Shoulder.
Hwy. 401, Port Hope.

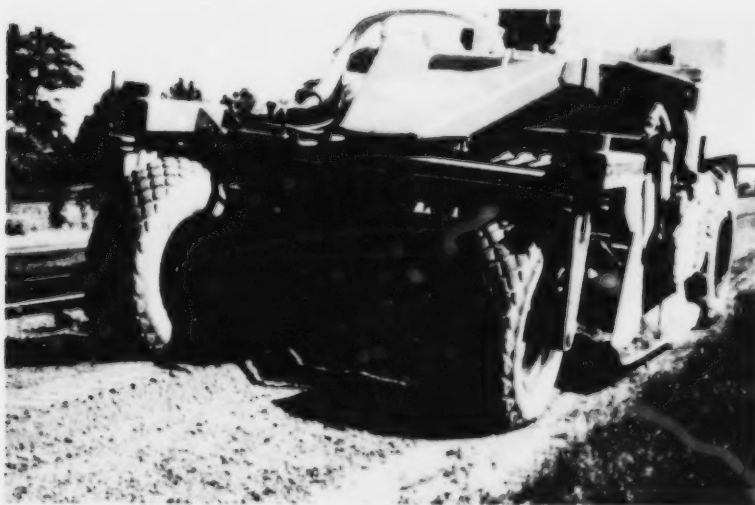


Figure 6. View of Pulverizing Machine.
Hwy. 401, Port Hope.

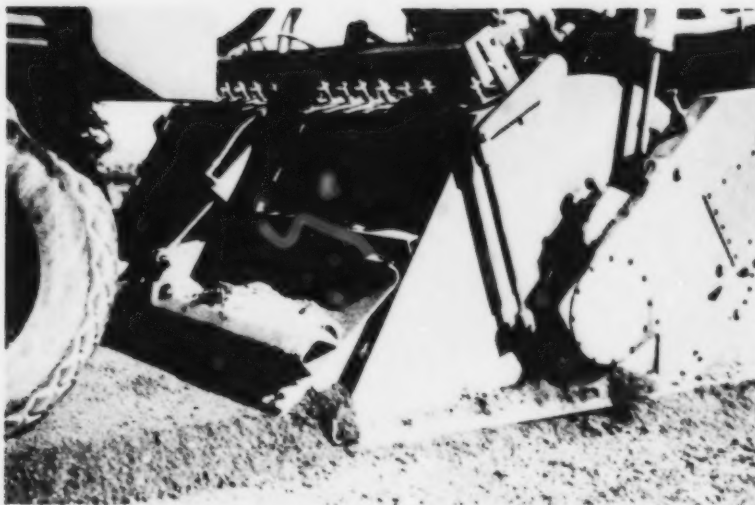


Figure 7. Pulverizer Blending R.B.M. with Granular. Hwy. 401 Port Hope.



Figure 8. Shoulder Appearance after Blending. Hwy. 401 Port Hope.



Figure 9. Shaping and Compacting Blended Material. Hwy. 401 Port Hope.

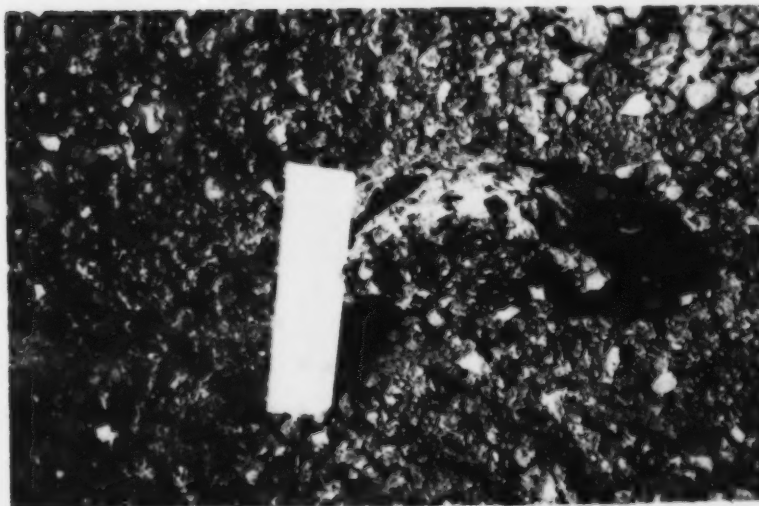


Figure 10. Fragment of Pavement > 50 mm in Diameter. Hwy. 401 Port Hope.

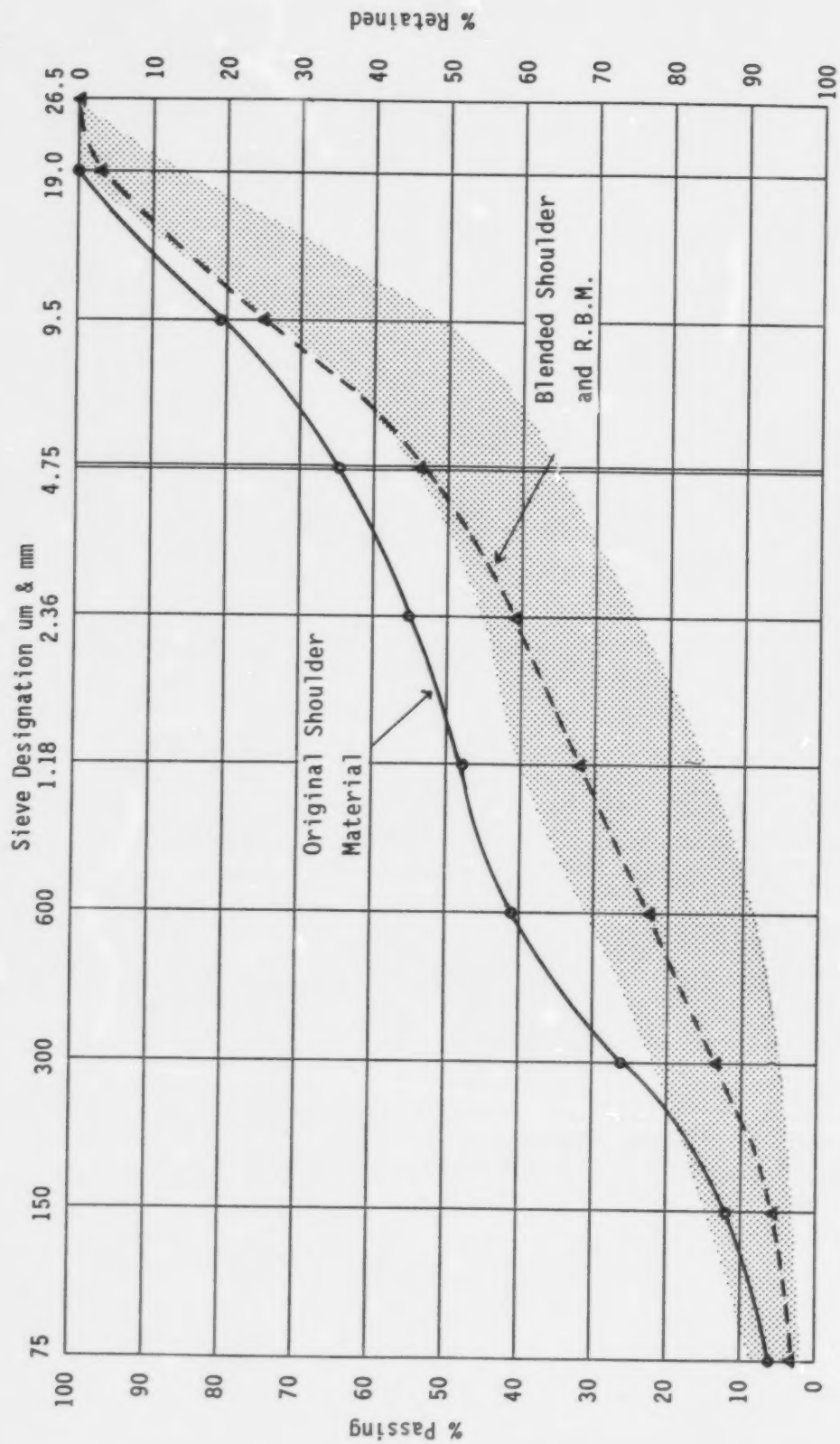


Figure 11. Highway 401 Experimental Project
Shoulder Materials.



Figure 12. 100 % R.B.M. Shoulder With Rut
at Pavement Edge. 88-59. Hwy.
401. Central Region.

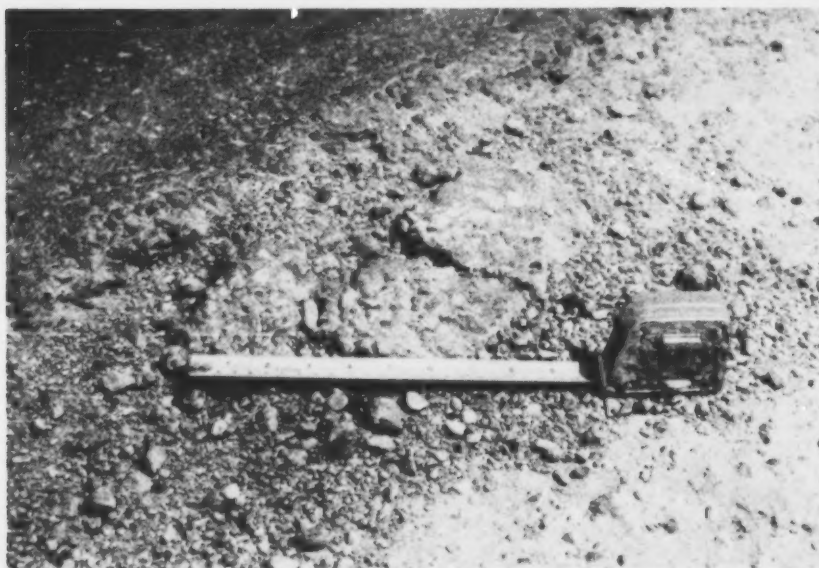


Figure 13. 100 % R.B.M. Shoulder With
Broken Chunks of R.B.M. 88-59.
Hwy. 401, Central Region.

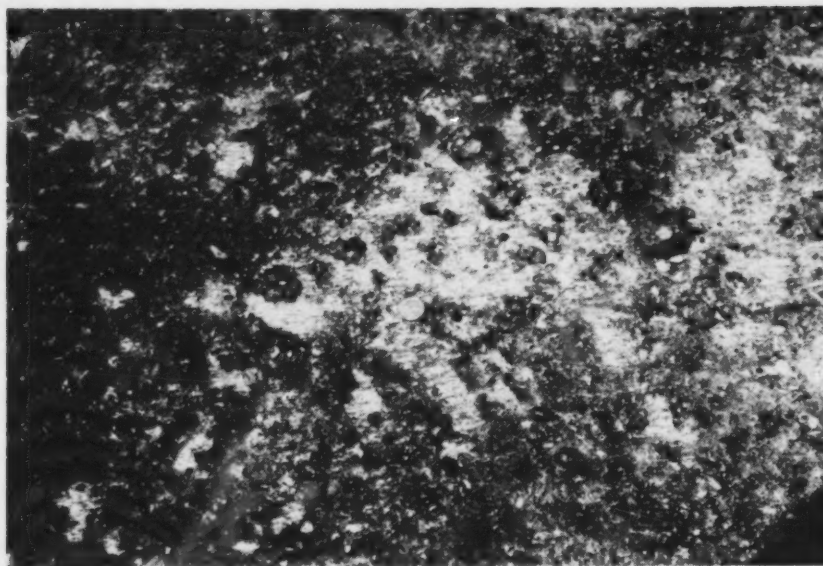


Figure 14. 100 % R.B.M. Shoulder With
Scrapes from Grader. 88-59.
Hwy. 401, Central Region.



Figure 15. 100 % R.B.M. Shoulder With
Badly Broken up Section. 88-59.
Hwy. 401, Central Region.

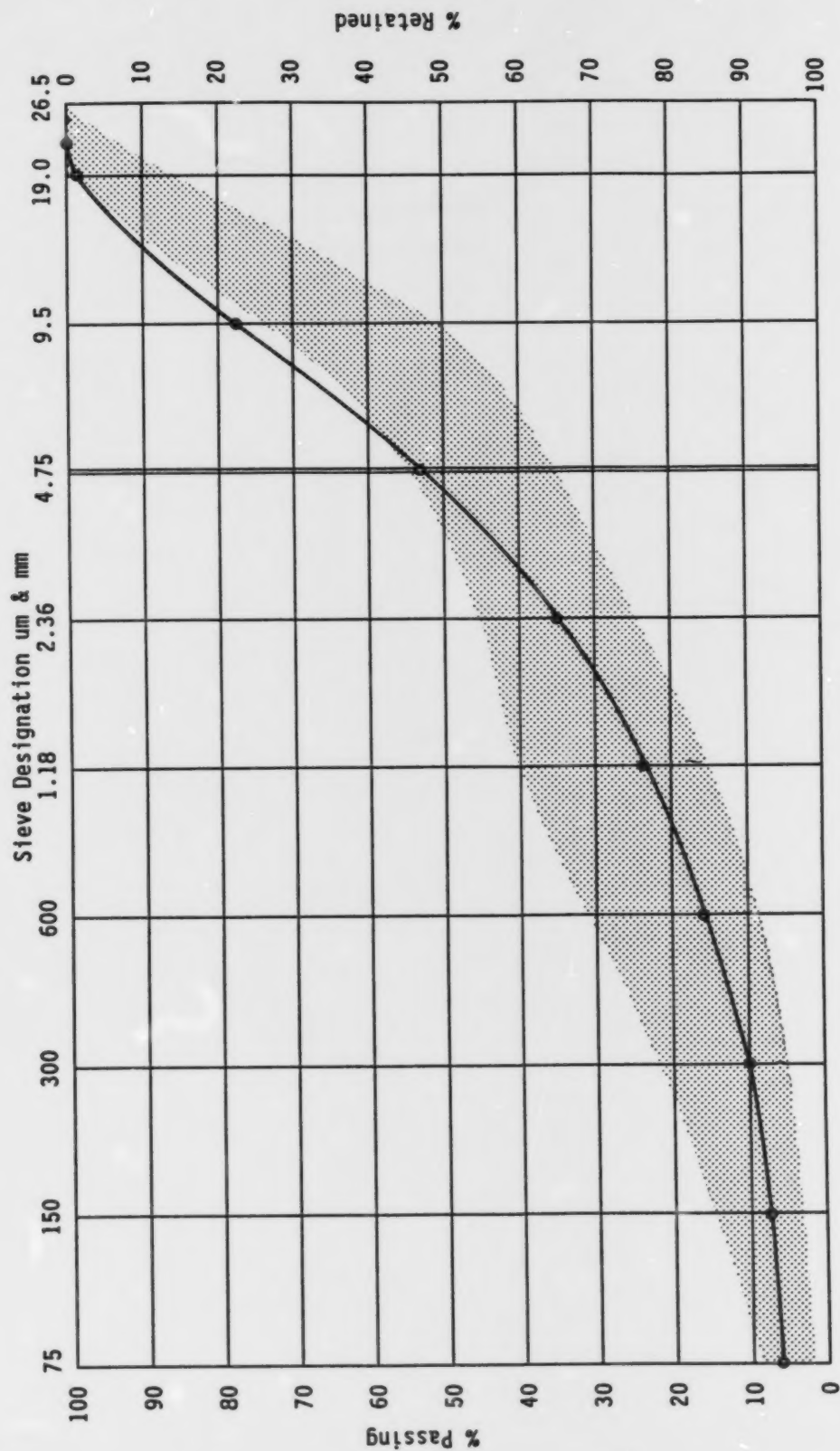


Figure 16. Pulverized Granular and Hot Mix Pavement. (Highway 54 - Central Reg.)

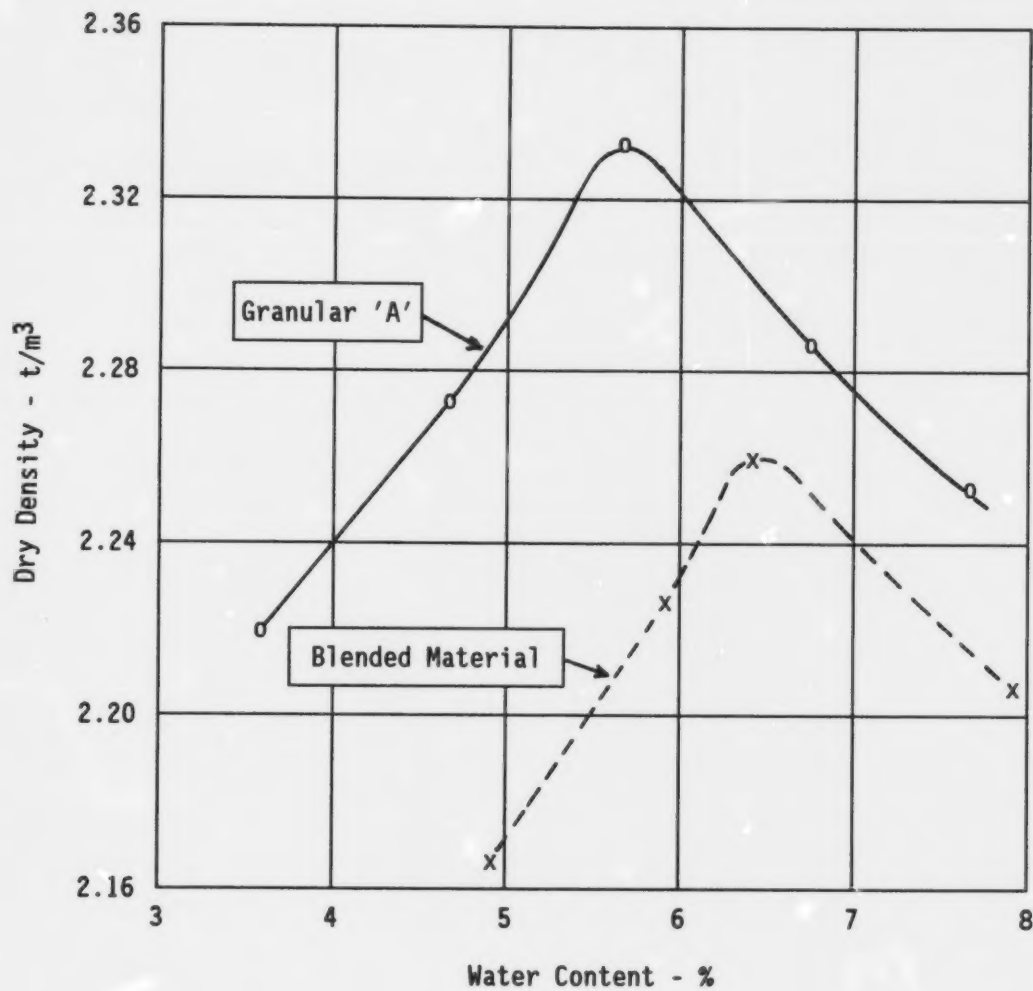


Figure 17. Compaction Tests. W.P. 78-79-05.
Hwy. 54, Central Region.

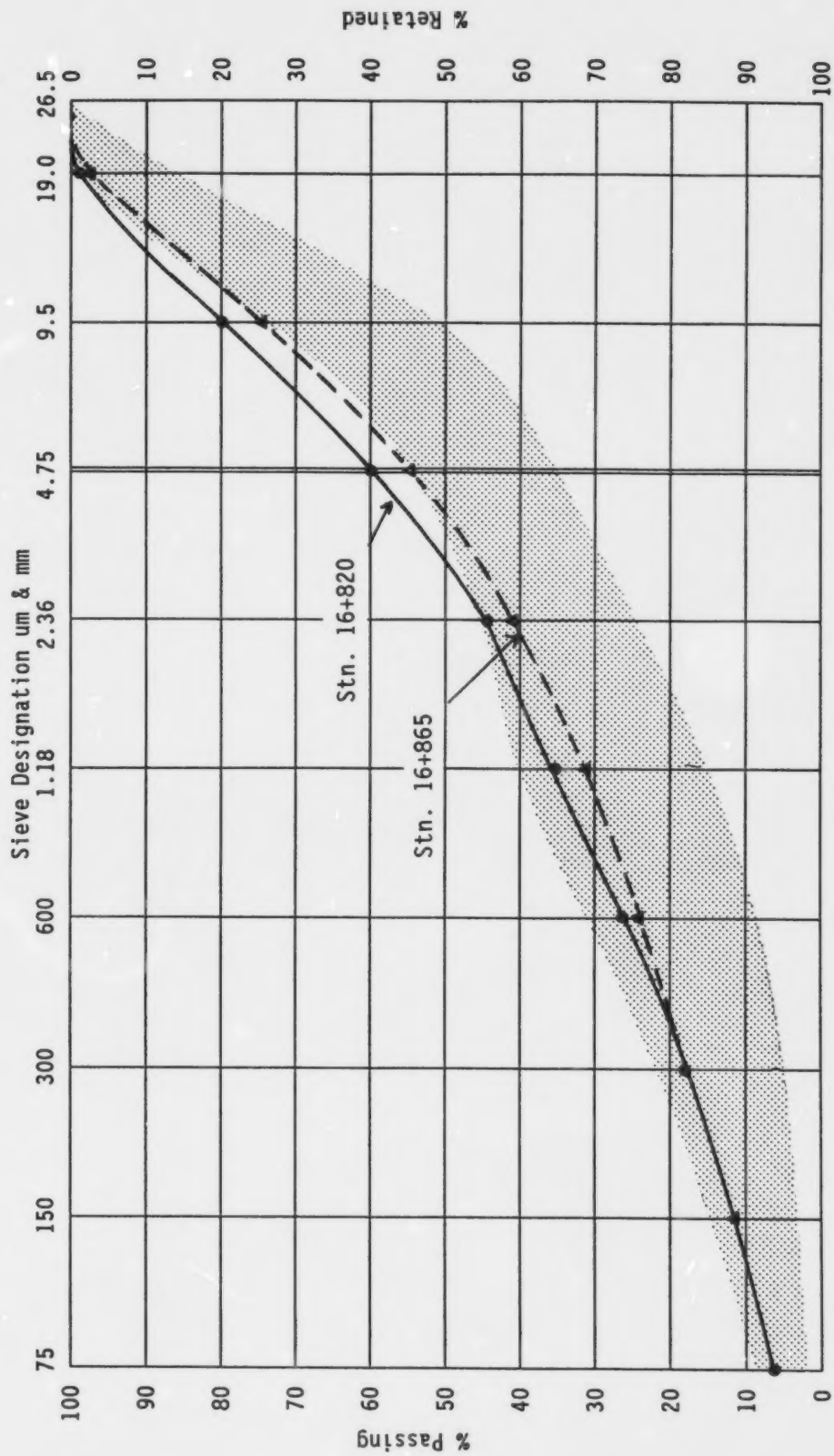


Figure 18. Pulverized Granular and Hot Mix Pavement. (Highway 38 - Eastern Reg.)



Figure 19. Pulverizer Mixing Pavement with
the Underlying Granular. 88-53.
Hwy. 515, Eastern Region.

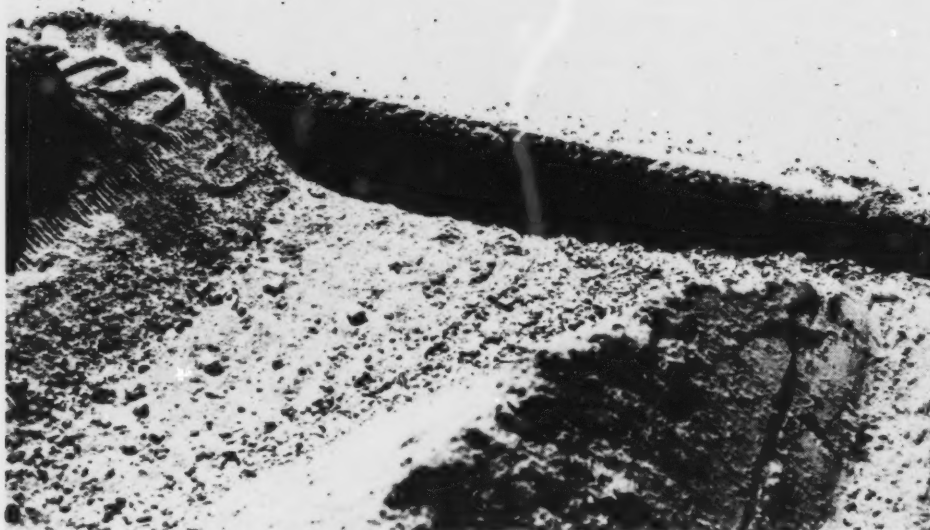


Figure 20. Edge of Cut Showing Depth.
88-53. Hwy. 515, Eastern
Region.

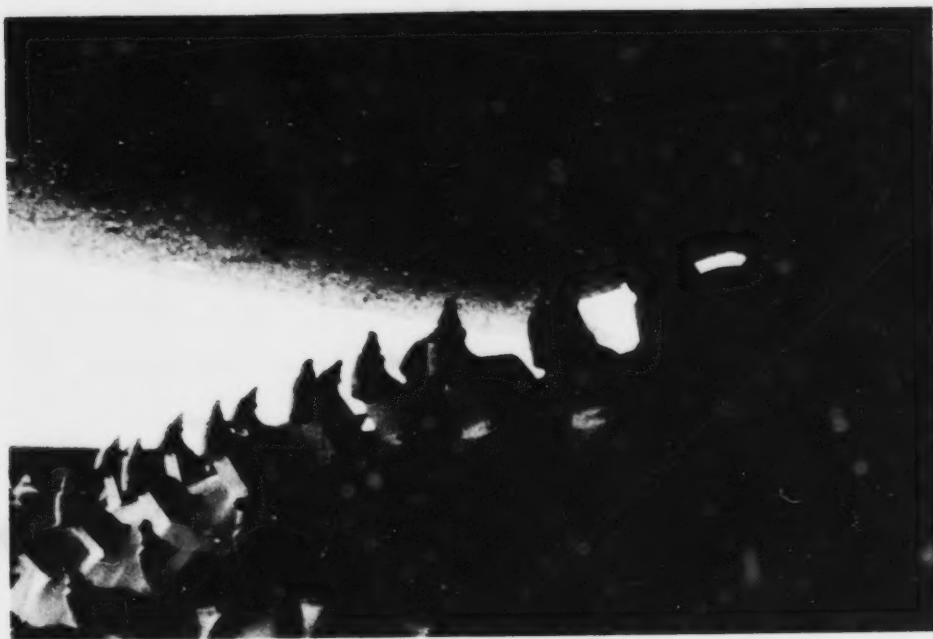


Figure 21. Teeth on Pulverizer Drum.
88-53. Hwy. 515, Eastern
Region.



Figure 22. Compacted Surface of Blended
Material. 88-53. Hwy 515,
Eastern Region.

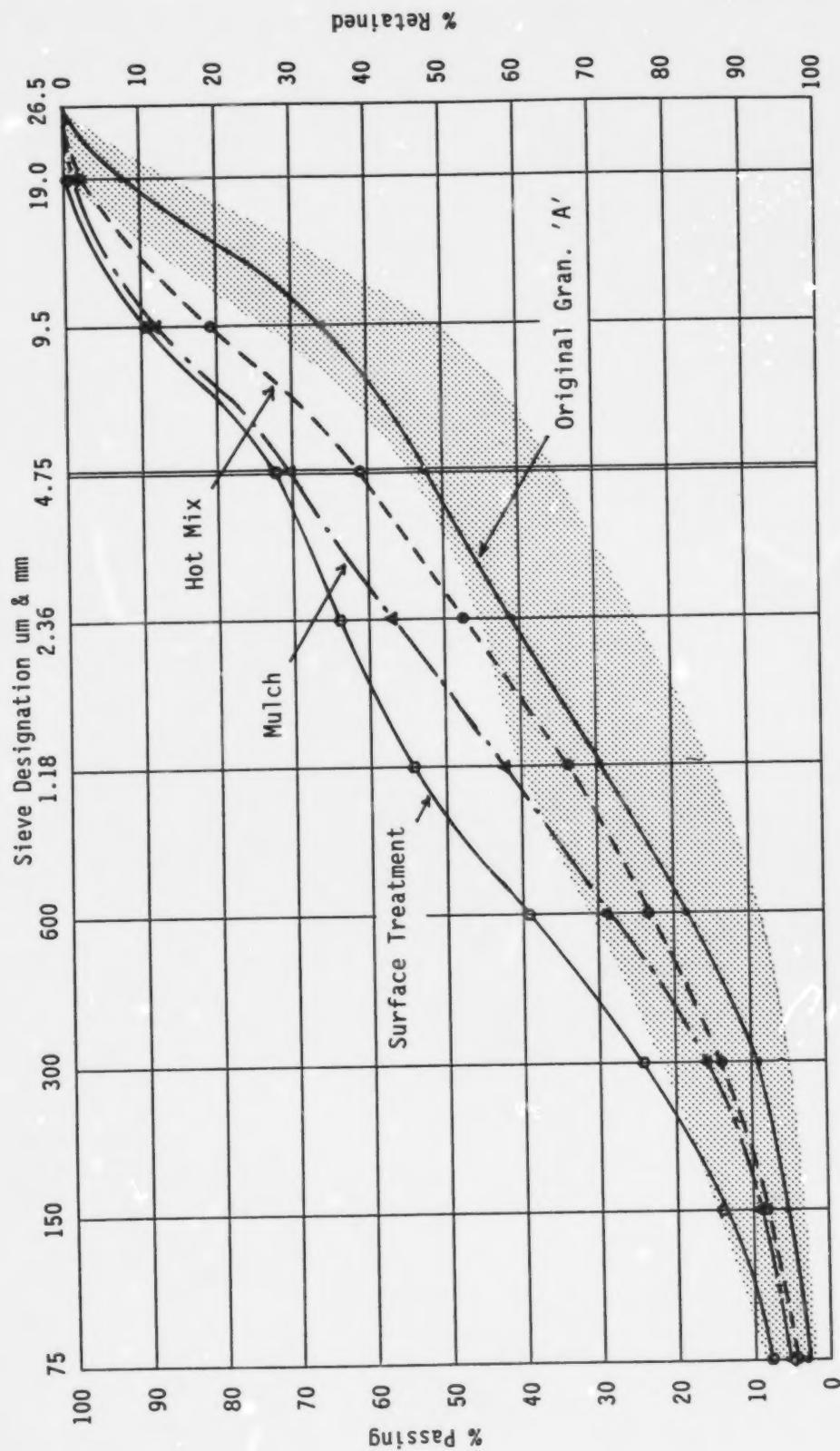


Figure 23. Three Bituminous Pavements Pulverized with Underlying Granular - (Highway 515, Cont. 88-53 - Eastern Reg.).

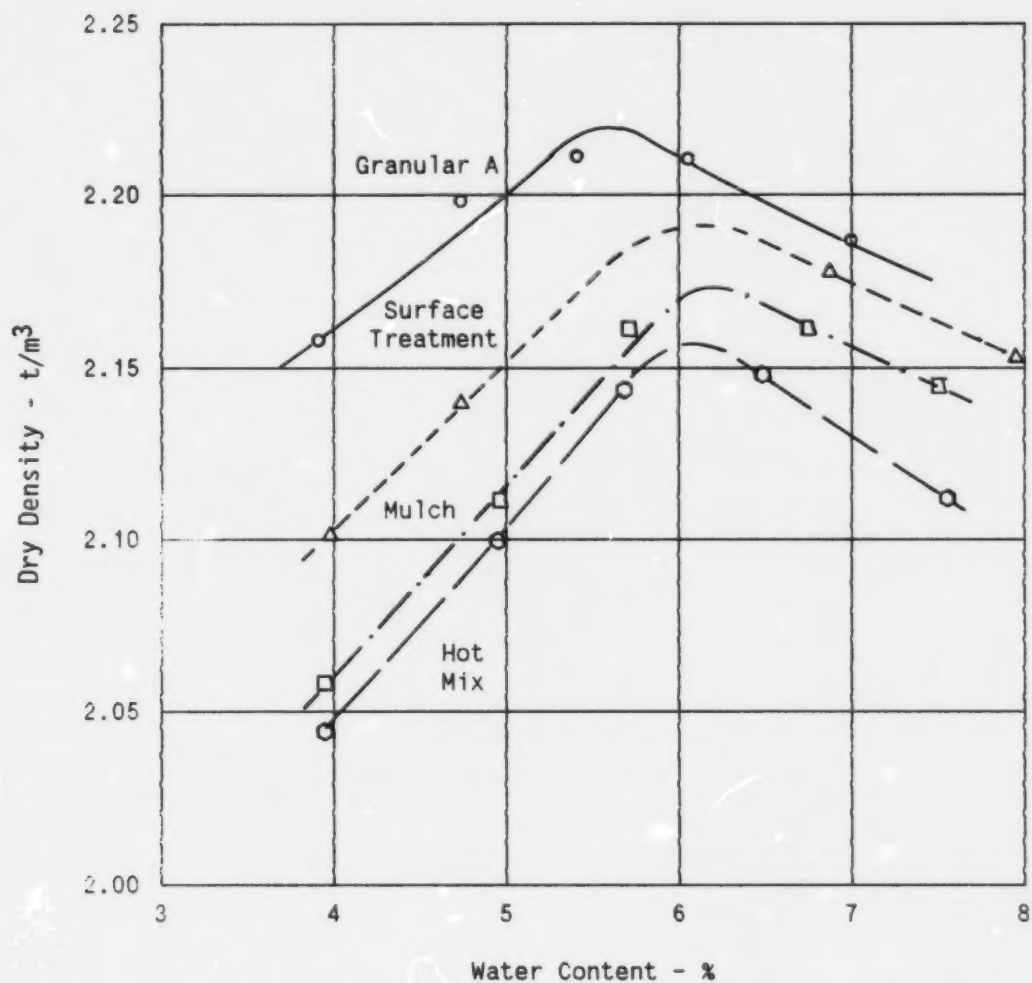


Figure 24. Lab. Compaction Data. 88-53.
Hwy. 515, Eastern Region.

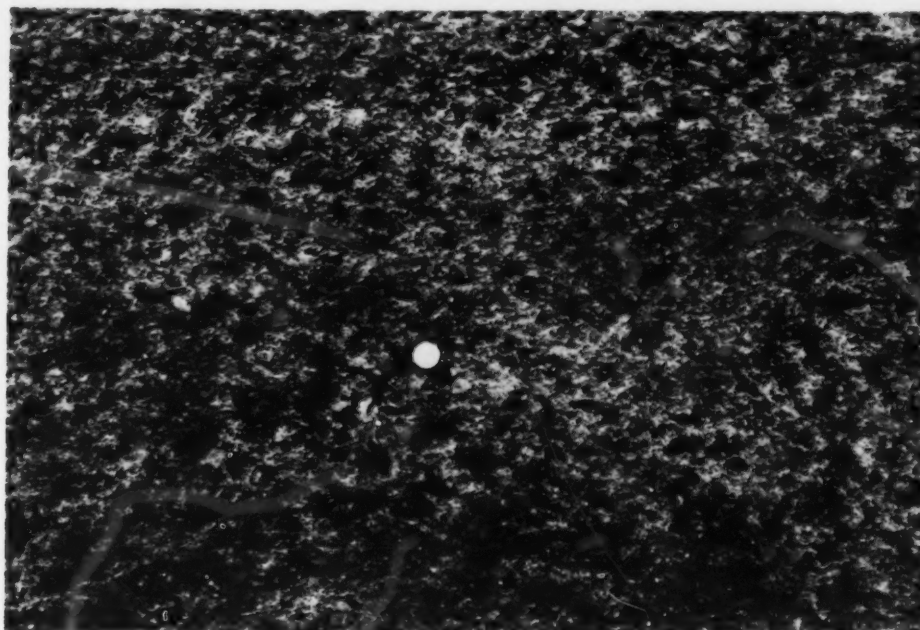


Figure 25. Close-up of Compacted Surface of
Blended Material. 88-41. Hwy.
507, Eastern Region.

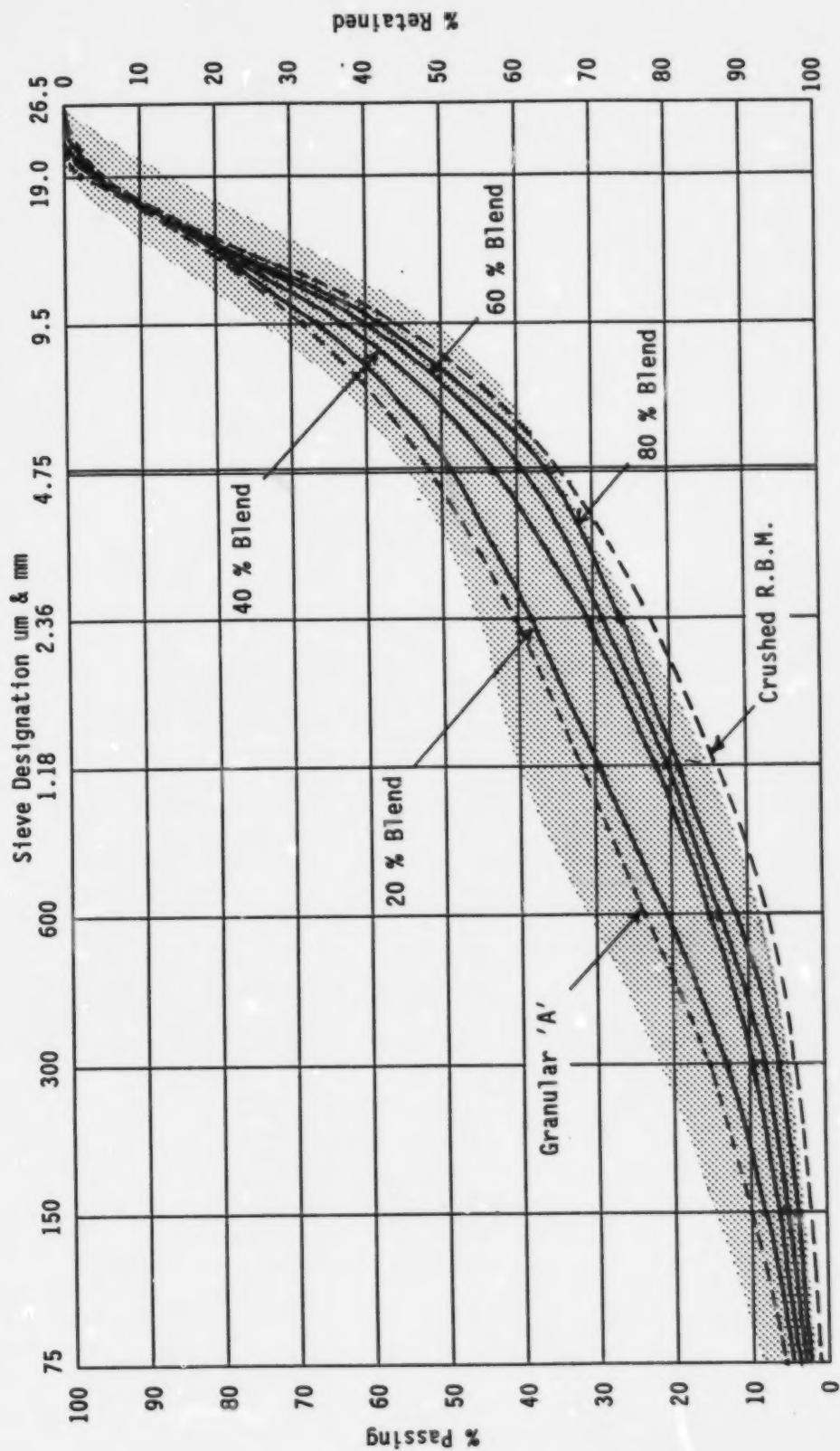


Figure 26. Laboratory Blended Materials.

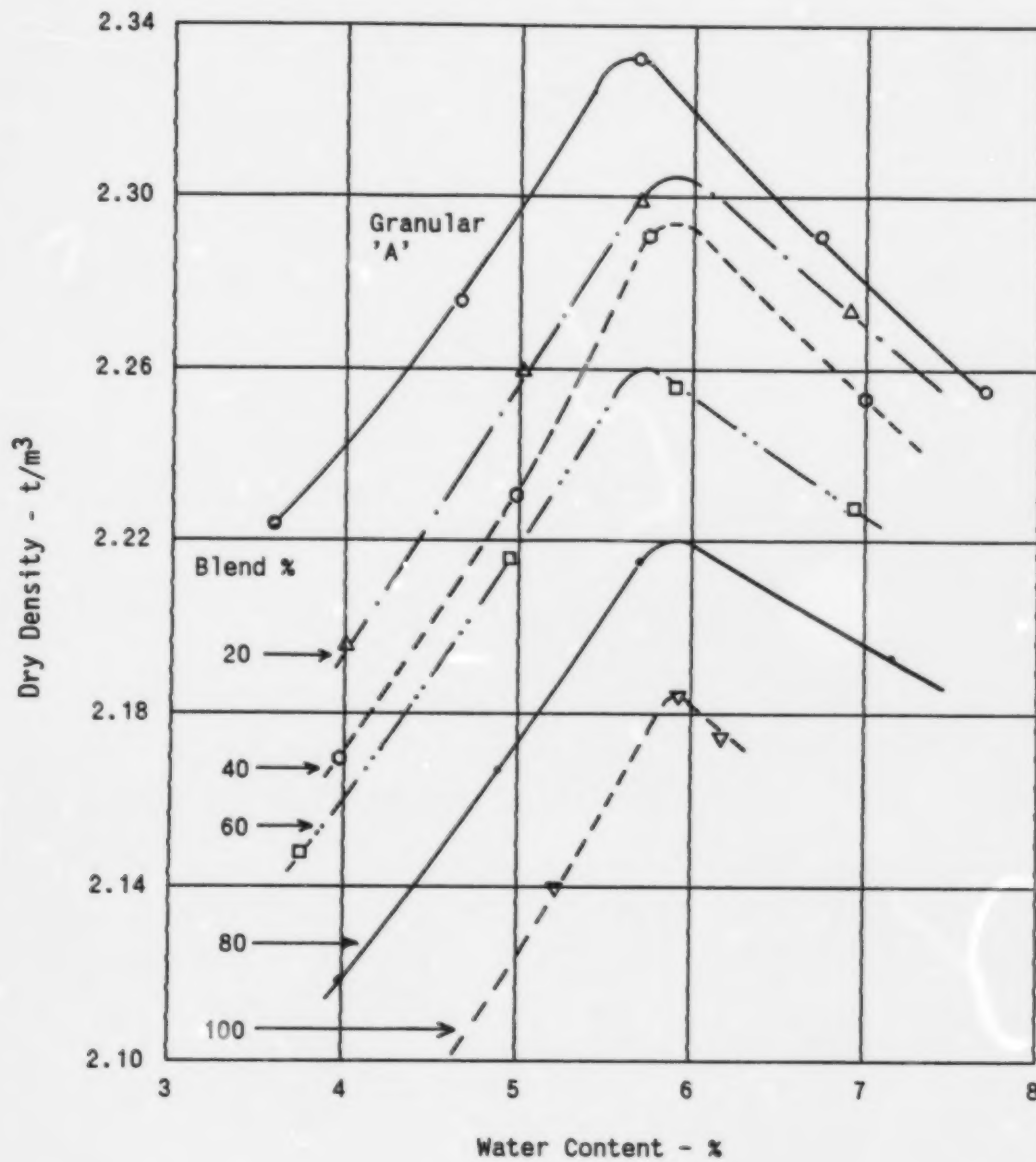


Figure 27. Laboratory Compaction Data.

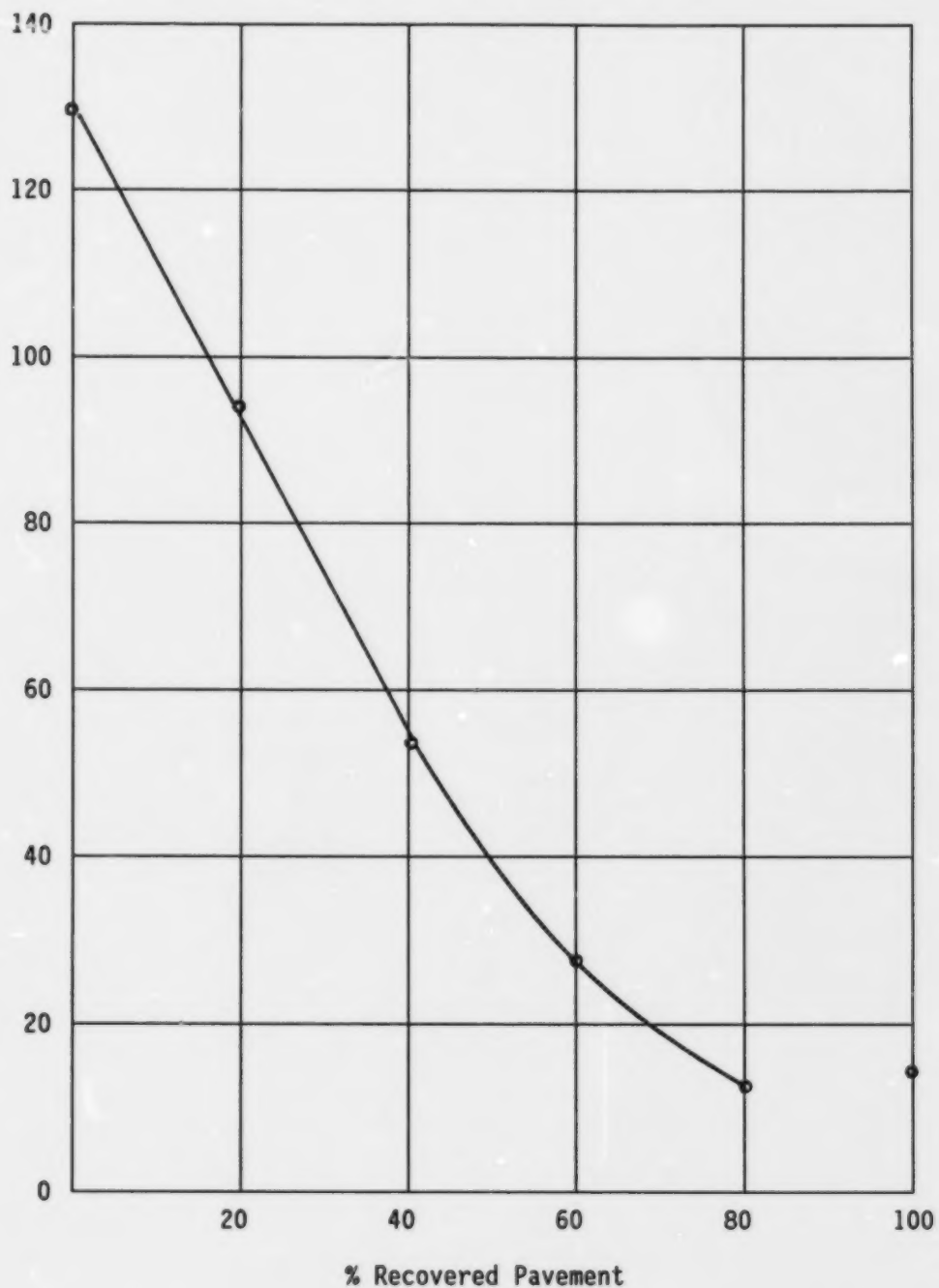


Figure 28. Lab. C.B.R. Data Varying R.B.M. %.
No Aging Time.

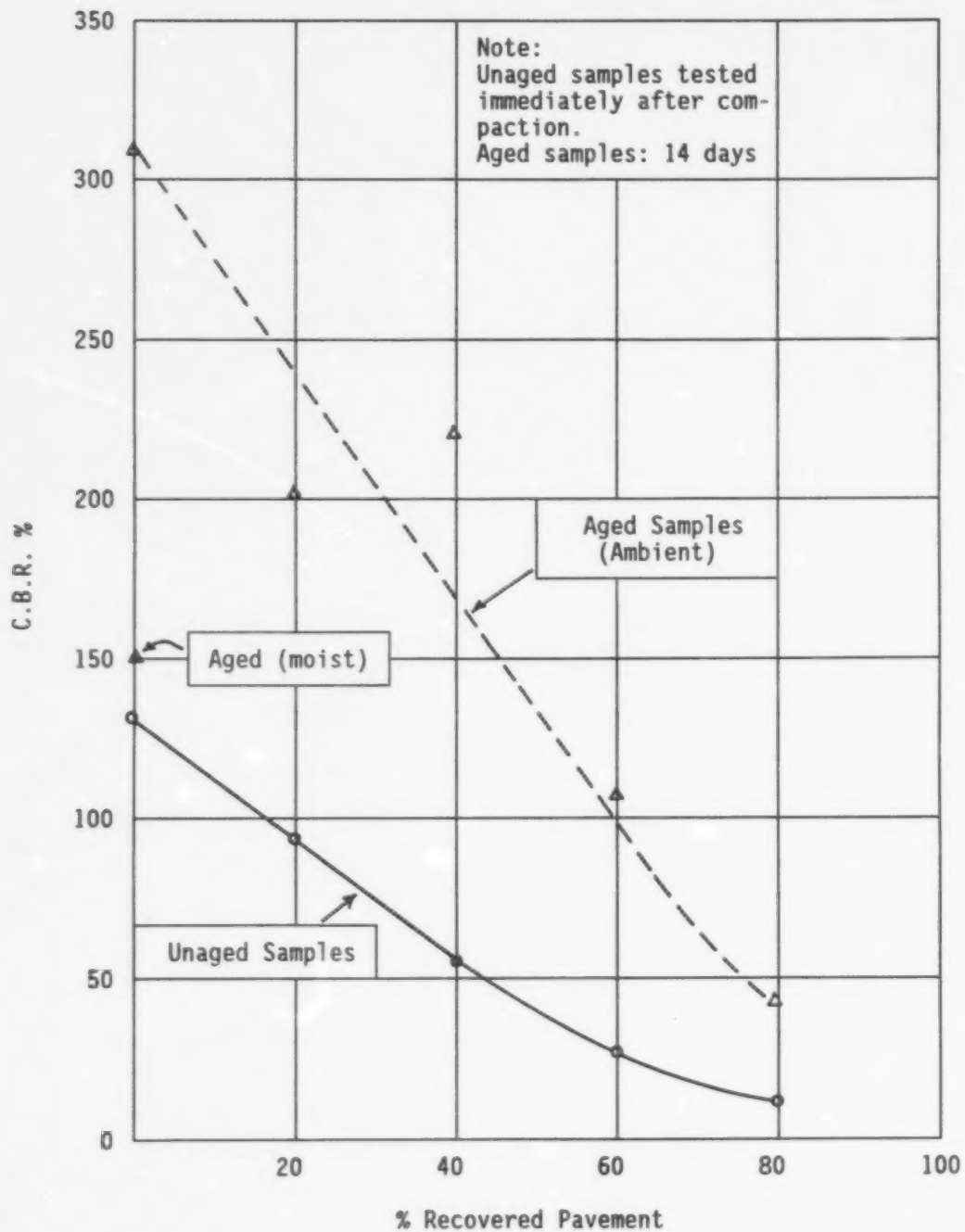


Figure 29. Effects of Aging.

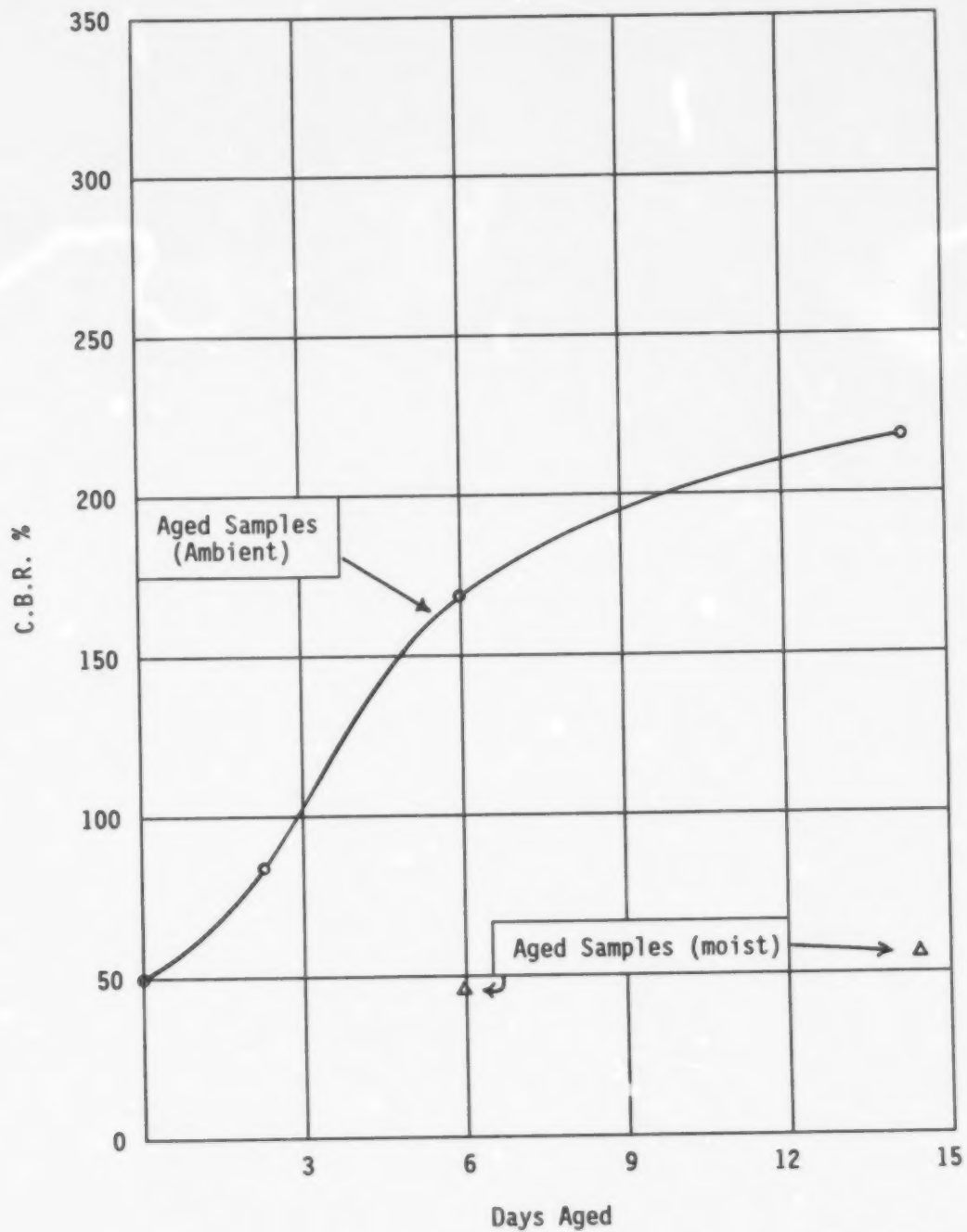


Figure 30. Aging of 40 % R.B.M. Mixture.

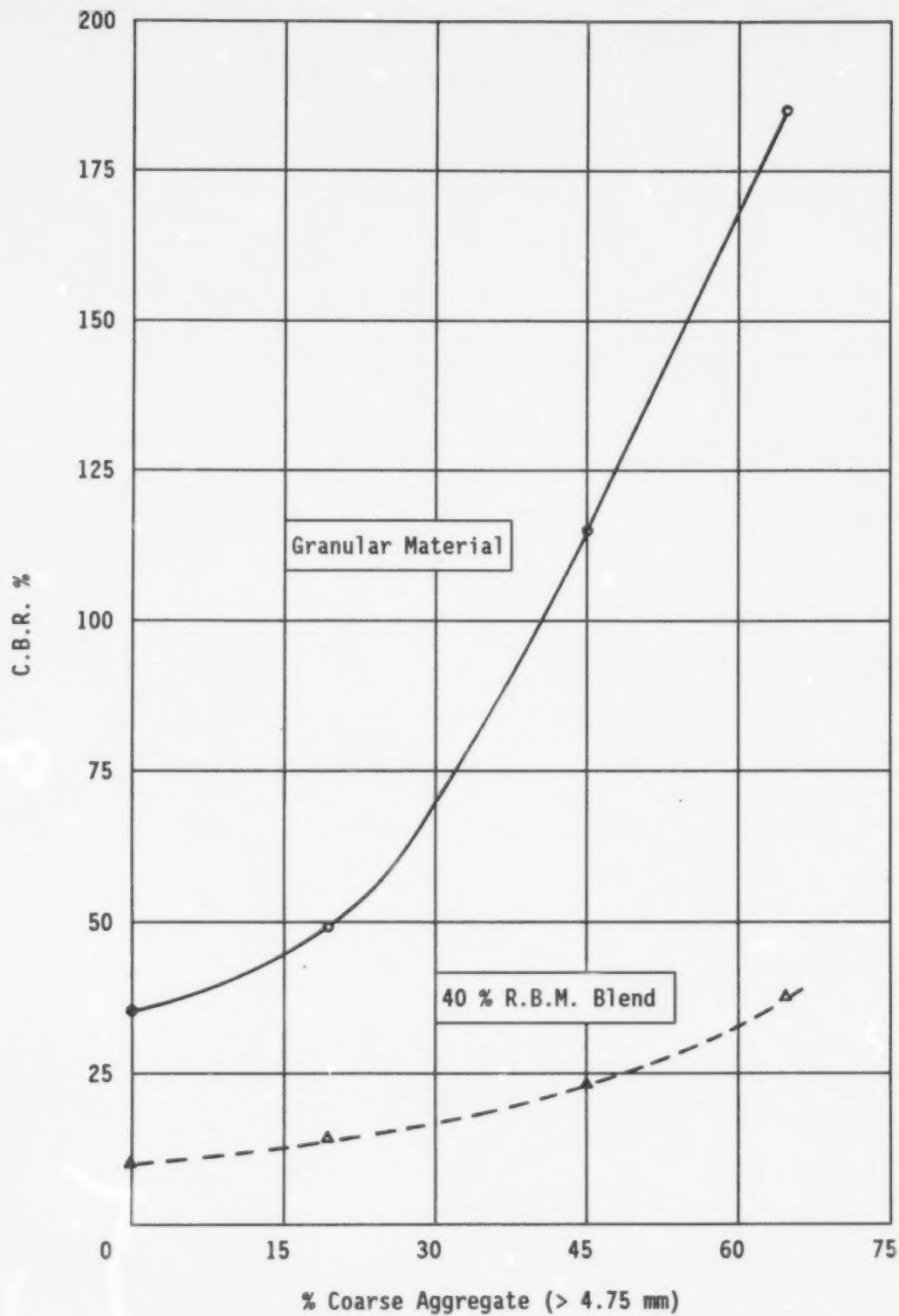


Figure 31. Effect of Fineness

APPENDIX D

SPECIAL PROVISIONS



1. Special Provisions from Previous Contracts

Special Provision - Contract 86-224 - Item No. (Northern Region).

PLACING AND COMPACTING PROCESSED ASPHALT PAVEMENT MATERIAL - Item No.

OPSS 314 is extended to include the placing of processed asphalt pavement material surplus to the Recycled Hot Mix requirements of this contract. It shall be used in lieu of conventional Granular A Type II shouldering.

For the purpose of compaction testing of the processed material a target density shall be determined by the roller sequence method. The Contractor shall supply a class C rubber-tired roller as per OPSS 310 and shall perform the roller sequence as required.

Payment at the contract price for the above tender item shall be full compensation for all labour, equipment and material required to do the work.

Special Provision - Contract 78-23 - Item No. (Northern Region).

1. Description

This special provision covers pulverizing of the asphalt pavement, asphalt curb and gutter and placing and compacting of pulverized material as a base course.

2. Materials

Flaked Calcium Chloride shall conform to the requirements of Form 2501. Calcium Chloride solution shall conform to the requirements of Form 506.

3. Construction

Where the pulverized asphalt pavement will be placed the same width as the existing pavement, the Contractor shall construct the existing shoulders flush with the existing pavement prior to pulverizing the adjacent asphalt pavement. The Contractor shall construct to the top of Granular A grade any sections where the pulverized asphalt pavement is to be spread wider than the existing pavement prior to pulverizing the existing adjacent asphalt pavement.

The Contractor shall sufficiently pulverize the existing asphalt pavement so that all the resultant material passes a two inch sieve.

The minimum thickness of pulverized asphalt pavement at any location on the cross-section shall be * 3 inches.

The Contractor shall exercise due care to prevent the pulverized asphalt pavement from becoming contaminated with the underlying granular materials.

The pulverized asphalt pavement shall be bladed and compacted to carry traffic.

The pulverized asphalt pavement shall be sprinkled with water when and as directed by the Engineer, either to aid compaction, reduce dust nuisance, or both. When water is added to aid compaction, it shall be applied immediately ahead of the compaction operation.

Calcium Chloride shall be applied uniformly by mechanical means when, and as directed by the Engineer.

The surface of the pulverized asphalt pavement shall be bladed, shaped and compacted as necessary to produce the required contour of the surface. The finished surface shall not deviate more than three-eighths inch at any place on a ten foot template.

The pulverized asphalt pavement in each layer shall be compacted to a minimum 100 % maximum density as determined by the current ASTM Standard moisture density test. The field density shall be determined by the nuclear method.

4. Measurement for Payment

Measurement for payment shall be made horizontally in square yards of asphalt pavement and adjacent asphalt curb and gutter pulverized.

5. Basis of Payment.

Payment at the contract price for the tender item shall be full compensation for all costs of breaking, removing and pulverizing the asphalt pavement and asphalt curb and gutter, regardless of thickness, for loading, hauling, windrowing and other handling as necessary, and for placing and compacting the pulverized asphalt pavement as required by the contract.

Measurement and Basis of Payment for water for compaction and dust control and Calcium chloride shall be according to Form 314.

Special Provision - Contract 82-211 (Northern Region)

RECLAIM MULCH PAVEMENT - FULL DEPTH - Item No. 17

Scope

This Special Provision covers the work of reclaiming existing mulch pavement to its full depth in place and compacting the processed mulch pavement material as base course material under the pavement area on the main roadway.

Construction

While reclaiming the mulch pavement, care shall be taken to prevent the mulch pavement from becoming contaminated with the underlying granular material. It shall be sufficiently processed so that all of the resultant material passes a 40 mm square sieve.

The surface of the processed material shall be bladed, shaped and compacted as necessary to produce the required cross section of the surface in accordance with Form 301. This material shall be compacted to a minimum 100 % maximum density as determined by the current MTO Standard Moisture Density Test. The Field Density shall be determined by the nuclear method.

Measure for Payment

Measurement and basis of payment for water and calcium for compaction and dust control shall be as per Form 501.

Measurement for reclaimed mulch pavement shall be in square metres, measured in place in a horizontal plane.

Basis for Payment

Payment at the contract price of the above item shall be full compensation for all labour, equipment and material required in the process to reduce the mulch material to the required size. It shall include blading, shaping and compacting the processed mulch pavement as base course.

REMOVE MULCH PAVEMENT AND SALVAGE FULL DEPTH - Item No. 18

Scope

This Special Provision covers the work of removing existing mulch pavement overlying excavation areas, full depth and stockpiling removed materials.

Construction

While removing the mulch pavement, care shall be taken to prevent the removed mulch pavement from becoming contaminated with granular materials.

The removed mulch pavement shall be stockpiled on a 150 mm sand pad at a suitable location agreed upon by the Engineer and the Contractor.

Measurement for Payment

Measurement for payment of the removed mulch pavement shall be in square metres measured in place in a horizontal plane.

Basis of Payment

Payment at the contract price of the above item shall be full compensation for all labour, equipment and material to do the above work.

PROCESS MULCH PAVEMENT FROM STOCKPILE - Item No. 19

Scope

This Special Provision covers the work of processing an existing 5300 t stockpile of mulch pavement and the stockpile formed under Item 18. It shall also include placing and compacting the resultant material as base course on the main roadway. The existing stockpile is located at MTO Pit in Lot 4, Concession IV, Township of Thistle.

Construction

The mulch pavement shall be processed and placed on the roadway as per Specification 314.

Measurement for Payment

Measurement for payment will be made in tonnes as specified in Form 501, Specifications For Weighing Material.

Basis of Payment

Payment at the contract price for the tender item, Process Mulch Pavement from Stockpile shall be full compensation for all labour and equipment to perform the work of this item.

Special Provision - Contract 88-223 (Northwestern Region).

GRANULAR A - Item No.

Payment at the contract price bid for the above tender item shall include full compensation for all labour, equipment and materials required for blending and stockpiling of approximately 5500 tonnes of surplus processed reclaimed asphalt pavement from stockpiles created under the item (Reclaim Asphalt Pavement - Full Depth). The surplus processed reclaimed asphalt pavement shall be blended with conventional Granular A and used in lieu of conventional Granular A.

Conventional Granular A materials shall be crushed and stockpiled separately to allow for acceptance/rejection testing by Ministry staff.

The materials, quality assurance and price adjustment requirements set out by special provision for Granular A shall apply only to Granular A. They shall not apply either to the surplus processed reclaimed asphalt pavement or the blended product. Price adjustments, where applicable, shall be applied using the quantity of the lot of conventional Granular A which does not meet the specification requirements and the tender price of this item.

The processed reclaimed asphalt pavement materials and conventional Granular A material shall then be progressively loaded into separate bins. Gate settings on each bin shall be set to achieve a uniform blend of both materials. A system of conveyor(s) will collect the materials from the bins. Blended materials shall be stockpiled

A maximum of 40 % by mass of the final product is to be reclaimed asphalt pavement.

Other means of achieving a uniform blend of materials may be permitted subject to receiving prior written approval of the Ministry. Blending on the road, during the production of either material or direct feeding from the crusher(s) to the conveyor belt(s) shall not be permitted.

Special Provision - Contract 88-61. (Southwestern Region)

PULVERIZE, PROCESS, SHAPE AND COMPACT ASPHALT PAVEMENT AND GRANULAR BASE COURSE IN PLACE - Item No.

After reclaiming the specified partial depth of the existing pavement, at the contract price for this item, the contractor shall provide all equipment, labour and materials required to:

- (a) Pulverize and process the remaining hot mix pavement to its full depth, in place, and thoroughly mix the material with an average 100 mm of the underlying granular base materials. It shall be sufficiently processed so that all of the mixed material passes a 37.5 mm sieve size.
- (b) Shape the surface of the processed material to the desired crossfall, width and profile, in accordance with OPSS 301 for restored surface.
- (c) Compact the mixed material in accordance with OPSS 501 for granular materials.
- (d) All the above within the same day, and the work operation not to exceed 1.0 km for any location on the roadway.
- (e) Immediately prior to placing the R.H.M., if necessary the base shall be reshaped and recompacted so that the grade will meet the requirements for crossfall, width and profile.

- (f) During the work, the contractor is to provide safe passage for single lane traffic during daylight working hours and two lane traffic at all other times, providing warning signs, flagmen and delineators as required by current MTO Traffic Control Manual.

Any surplus pulverized pavement in the "urban" areas shall be removed and may be incorporated with other sections and shall be paid for as extra work in accordance with Form 100 Subsection 103.3.

Reclaimed asphalt pavement surplus to the work shall become the property of the contractor and be disposed of outside the right-of-way.

Measurement for Payment

Measurement and basis of payment for water and calcium chloride for compaction and dust control shall be as per OPSS 501.

Measurement for processed, shaped and compacted asphalt and granular base material shall be in square metres, measured in place in a horizontal plane.

Basis for Payment:

Payment at the contract price for the above item shall be full compensation for all labour, equipment and materials required to process the asphalt pavement to the required size and mix with the granular base. It shall also include shaping and compacting the processed pavement/granular base course until paved.

Special Provision - Contract 88-47. (Central Region)

RECLAIM AND PROCESS EXISTING ASPHALT PAVEMENT/GRANULAR BASE COURSE - Item No.

Scope

This special provision covers the work of reclaiming existing asphalt pavement and granular to a depth of 150 mm in place and compacting the processed materials as base course under the pavement on the road.

Construction

While reclaiming the existing asphalt pavement (80 mm average in thickness), the Contractor shall ensure that the existing asphalt pavement and the granular base course are thoroughly mixed to a depth of 150 mm. It shall be sufficiently processed so that 100 % of the mixed material passes a 37.5 mm sieve size.

The surface of the processed material shall be bladed, shaped and compacted as necessary to produce the required tolerance in accordance with OPSS 301 and to cross-sections shown on the drawings. The material shall be compacted to a minimum 100% density as determined by the current MTO Standard Moisture Density Test. The field density shall be determined by the nuclear method. The reclaiming and processing shall be worked to the same station prior to closing down operations each day.

Measurement for Payment

Measurement for reclaimed existing asphalt pavement shall be in square metres, measured in place in a horizontal plane.

Basis of Payment

Payment at the contract price for the above tender item shall be full compensation for all labour, equipment and material required to do the work.

Special Provision (New) - Contract 88-77. (Central Region)

OPERATIONAL CONSTRAINT

Provisions for Traffic

Due to the heavy traffic throughout the construction site, the Ministry wishes to minimize the time the travelling public is required to travel on the granular base.

Incentive/Disincentive Provisions

For the purpose of administering the incentive/disincentive provisions, the contract will be divided into 1 km sections, including Each section will be the full width of pavement and the precise location of each section will be determined prior to the start of work on the contract. Each 1 km section will be treated as a separate entity, and for each section a day will be counted for each calendar day, or portion thereof, that any portion of the pavement is removed full depth. The counting of days will cease when the entire section is covered with the first binder course of pavement.

Incentive Payment/Disincentive Deduction

When a section is completed (first binder course placed) in less than 20 calendar days, the contractor will be paid an incentive of \$200.00 per calendar day for each day less than 20 days. For each section where the contractor exceeds 20 days for the completion, as specified, the Ministry will deduct from contract payments \$200.00 per calendar day for each day in excess of the 20 days.

If the section is completed in exactly 20 days incentives and disincentives will not apply.

Special Provision - Contract 88-59. (Central Region)

EXCAVATE FOR AND PLACE RECLAIMED ASPHALT PAVEMENT ON SHOULDERS - Item No. 6

Construction

The Contractor shall excavate the existing shoulders as shown on the contract drawings and place on the adjacent shoulder.

Reclaimed pavement from Hwy. 401 Binder Course shall be placed on the outside shoulder of Hwy. 401 as shown on the contract drawings, excluding all interchanges. The shoulders shall be rolled with three passes of a steel wheeled roller (Min. Class 'B').

Reclaimed asphalt pavement surplus to the work shall become the property of the Contractor and be disposed of outside the right-of-way.

Measurement for Payment

Measurement for payment of the reclaimed asphalt pavement shall be in metres according to the requirements of OPSS 510.

Basis of Payment

Payment at the contract price for the above tender item shall be full compensation for all of the shoulder grading, labour, equipment and material required to do the above work.

2. Generalized Special Provisions

SPECIAL PROVISIONS FOR THE USE OF RECOVERED MATERIALS

a) Trial Contracts with Contractor's Optional use of removed bituminous pavement:

<u>Activity</u>	<u>Special Provision</u>	<u>Implementation</u>
Use of recovered materials in embankments	102S07	89 09 01
Mixing recovered bituminous pavement with granular to 40%	314S01	89 09 01

b) Regular Contracts

<u>Activity</u>	<u>Special Provision</u>	<u>Implementation</u>
Use of recovered materials in embankments	102S06	89 09 01
Mixing recovered bituminous pavement with granular to 30%	314S02	89 09 01
Use of recovered concrete as granular A, B, M.	110S04	89 09 01
Change in Definition	105S09	89 09 01

c) Geotechnical Options

<u>Activity</u>	<u>Special Provision</u>	<u>Implementation</u>
Recovered bituminous pavement on shoulders	399F34	89 09 01
In-place processing of bituminous pavement	399F35	89 09 01

a) Trial Contracts with Contractor's Optional use of removed bituminous pavement:

Special Provision No. 102S07

June 1989.

Use of Recovered materials in Embankments

Definitions

Section 206.03 Definitions is amended by the addition of the following:

Recovered Material: means bituminous pavement or Portland cement concrete which has been salvaged. For the purposes of compaction, this material shall be treated as earth when included in the subgrade.

Embankments

Clause 206.07.01.02 of OPSS 206 is amended by the addition of the following:

The Contractor shall ensure recovered materials used for embankment construction conform to the following requirements as specified in clauses 206.07.05.02, .03 and .07.

Layer Compaction Method

Clause 206.07.05.02 of OPSS 206 is amended by deleting the last sentence in the first paragraph and replacing it with the following:

All boulders, cobbles, fragments of rock and recovered materials over 0.15 m in their greatest dimension shall be removed and disposed of.

Modified Layer Compaction Method

Clause 206.07.05.03 of OPSS 206 is amended as follows:

Delete the second sentence in the first paragraph and replace it with the following:

Apart from the depth of material, placement of embankment material shall conform to clause 206.07.05.02 except that the maximum size of boulders, cobbles, fragments of rock and recovered materials shall not exceed the compacted Modified Layer depth or 0.3 m, whichever is the lesser.

Delete the last paragraph and replace with the following:

Boulders, cobbles, fragments of rock and recovered materials over 0.15 m in their maximum dimension shall not be placed within 0.30 m of the surface of the earth grade.

Earth Embankments

Subsection 206.07.05 of OPSS 206 is amended by the addition of the following:

206.07.05.07 Boulders and Fragments

Boulders, cobbles, fragments of rock and recovered materials up to 0.5 m³ may be incorporated into an embankment provided:

- (a) they are placed only in the bottom layer of the embankment;
- (b) the maximum dimension of the largest particle shall not exceed 0.8 m;
- (c) they are not located within 0.3 m of the final embankment side slopes;
- (d) they are not located within 1.0 m of the surface of the earth grade.

Warrant: On trial contracts which permit the contractor's optional use of recovered bituminous or concrete pavement. The trial contracts will be recommended by the Manager, Regional Engineering Right of Way and the Head, Design Evaluation and Pavement Section, Downsview. THIS NSSP IS PART OF A PACKAGE AND IS NOT TO BE USED ON OTHER CONTRACTS.

GRANULAR A - Item No.
GRANULAR B - TYPE I - Item No.
GRANULAR B - TYPE II - Item No.
GRANULAR M - Item No.

Page 1 of 2

Special Provision No.314S01

June 1989

Mixing Recovered Bituminous Pavement with Granular to 40%

MATERIALS

Section 314.05 of OPSS 314, September 1988 is amended by the addition of the following:

314.05.02 Recovered Bituminous Pavement for Blending with Granular

The Contractor may blend the recovered bituminous pavement with a previously tested and accepted granular material such that the blended product contains no more than 40 % recovered bituminous pavement by mass. If the granular material consists of crushed Portland cement concrete containing a percentage of bituminous pavement, this percentage must be included in the total amount of bituminous material in the blended product. The recovered bituminous pavement and granular material shall be uniformly blended to have 100 % passing the 26.5 mm sieve and not more than 75% passing the 4.75 mm sieve. It shall be stockpiled in accordance with the stockpiling requirements for coarse aggregates in subsection 1001.07.05 of OPSS 1001, May 1988.

The Contractor shall ensure that the recovered bituminous pavement does not include steel slag aggregate materials.

314.05.03 Recovered Bituminous Pavement for Mixing on Shoulders

The recovered bituminous pavement shall have 100 % passing the 26.5 mm sieve and no more than 75 % passing the 4.75 mm sieve.

CONSTRUCTION

Shoulders

Clause 314.07.03.02 of OPSS 314 is amended by the addition of the following:

The Contractor may place recovered bituminous pavement on the shoulder in lieu of granular. The Contractor shall prepare the existing shoulder to the specified crossfall and spread any surplus material on the adjacent section of the undisturbed shoulder. The recovered material shall be uniformly processed with the underlying granular by mechanical means such that no more than 40 % by mass of recovered bituminous pavement is incorporated with the underlying granular.

Warrant: On trial contracts which permit the contractor's optional use of recovered bituminous pavement. The trial contracts will be recommended by the Manager, Regional Engineering Right of Way and Head, Design Evaluation and Pavement Section, Downsview. THIS SPECIAL PROVISION IS PART OF A PACKAGE AND IS NOT TO BE USED ON OTHER CONTRACTS.

b) Regular Contracts

Special Provision No.102S06

June 1989.

Use of Recovered materials in Embankments

Definitions

Section 206.03 Definitions is amended by the addition of the following:

Recovered Material: means bituminous pavement surplus to the recycled hot mix requirements or Portland cement concrete which has been salvaged. For the purposes of compaction, this material shall be treated as earth when included in the subgrade.

Embankments

Clause 206.07.01.02 of OPSS 206 is amended by the addition of the following:

The Contractor shall ensure recovered materials used for embankment construction conform to the following requirements as specified in clauses 206.07.05.02, .03 and .07 of OPSS 206.

Layer Compaction Method

Clause 206.07.05.02 of OPSS 206 is amended by deleting the last sentence in the first paragraph and replacing it with the following:

All boulders, cobbles, fragments of rock and recovered materials over 0.15 m in their greatest dimension shall be removed and disposed of.

Modified Layer Compaction Method

Clause 206.07.05.03 of OPSS 206 is amended as follows:

Delete the second sentence in the first paragraph and replace it with the following:

Apart from the depth of material, placement of embankment material shall conform to clause 206.07.05.02 except that the maximum size of boulders, cobbles, fragments of rock and recovered materials shall not exceed the compacted Modified Layer depth or 0.3 m, whichever is the lesser.

Delete the last paragraph and replace with the following:

Boulders, cobbles, fragments of rock and recovered materials over 0.15 m in their maximum dimension shall not be placed within 0.30 m of the surface of the earth grade.

Earth Embankments

Subsection 206.07.05 of OPSS 206 is amended by the addition of the following:

206.07.05.07 Boulders and Fragments

Boulders, cobbles, fragments of rock and recovered materials up to 0.5 m^3 may be incorporated into an embankment provided:

- (a) they are placed only in the bottom layer of the embankment;
- (b) the maximum dimension of the largest particle shall not exceed 0.8 m;
- (c) they are not located within 0.3 m of the final embankment side slopes;
- (d) they are not located within 1.0 m of the surface of the earth grade.

Warrant: Always with OPSS 206

GRANULAR A - Item No.
GRANULAR B - TYPE I - Item No.
GRANULAR B - TYPE II - Item No.
GRANULAR M - Item No.

Special Provision No. 314S02

June 1989

Mixing Recovered Bituminous Pavement with Granular to 30%

MATERIALS

Section 314.05 of OPSS 314, September 1988 is amended by the addition of the following:

314.05.02 Recovered Bituminous Pavement for Blending with Granular

The Contractor may blend the recovered bituminous pavement with a previously tested and accepted granular material such that the blended product contains no more than 30 % recovered bituminous pavement by mass. If the granular material consists of crushed Portland cement concrete containing a percentage of bituminous pavement, this percentage must be included in the total amount of bituminous material in the blended product. The recovered bituminous pavement shall be material obtained from the contract which is surplus to the recycled hot mix requirements, or shall be from any other source. The recovered bituminous pavement and granular material shall be uniformly blended to have 100 % passing the 26.5 mm sieve and not more than 75 % passing the 4.75 mm sieve. It shall be stockpiled in accordance with the stockpiling requirements for coarse aggregates in subsection 1001.07.05 of OPSS 1001, May 1988.

The Contractor shall ensure that the recovered bituminous pavement does not include steel slag aggregate materials.

Warrant: Always with OPSS 314, September 1988.

AMENDMENT TO OPSS 1010, MAY 1988

Special Provision No.110S04

June 1989

Use of Recovered Concrete as Granular A, B & M

Material

Subsections 1010.05.02 and 1010.05.03 of OPSS 1010, May 1988 are deleted and replaced with the following:

1010.05.02 Granular A and M Aggregates

Granular A & M aggregates shall consist of crushed quarried material, or a mixture of crushed gravel, sand and fines produced from naturally formed deposits, or crushed slag produced from iron blast furnace or blended nickel slag, or recovered Portland cement concrete containing less than 20 per cent by mass of asphalt coated material as determined by petrographic examination.

Steel slag shall not be used.

Granular A and M aggregates from natural or slag sources shall conform to Tables 1 and 2. Recovered Portland cement concrete shall conform to Table 2.

1010.05.03 Granular B

Granular B aggregates shall be composed of clean, hard, durable uncoated particles obtained from deposits of gravel or sand, talus rock, quarried rock, iron blast furnace or blended nickel slag, clinkers, or recovered Portland cement concrete containing less than 20 per cent by mass of asphalt coated material as determined by petrographic examination, or other suitable granular materials.

Type I does not require crushing except that the Contractor may elect to either screen out or crush any oversize present. Type II shall only be obtained from quarried rock.

Granular B aggregates from natural or slag sources shall conform to Tables 1 and 2. Recovered Portland cement concrete shall conform to Table 2.

Steel slag shall not be used.

Warrant: Always with OPSS 1010, May 1988.

AMENDMENT TO OPSS 501, DECEMBER 1987

Special Provision No.105S09

June 1989

Recovered Material

DEFINITIONS

Section 501.03 of OPSS 501, December 1987 is amended as follows:

The third definition, Reclaimed Material is deleted and replaced by the following:

Recovered Material: means bituminous pavement or Portland cement concrete which has been salvaged. For compaction purposes, this material shall be treated as earth when included in the subgrade, and granular when included in the subbase, base or shoulders.

Warrant: Always with OPSS 501, December 1987.

c) Geotechnical Options

RECOVERED BITUMINOUS PAVEMENT ON SHOULDERS - Item No.

Special Provision No. 3969F34

June 1989

Recovered Bituminous Pavement on Shoulders

Scope

This special provision covers the requirements for placing recovered bituminous pavement on shoulders.

Material

The recovered bituminous pavement shall have 100 % passing the 26.5 mm sieve and not more than 75 % passing the 4.75 mm sieve.

Construction

The Contractor shall prepare the existing shoulder to the specified crossfall and spread any surplus material on the adjacent section of the undisturbed shoulder.

Shoulder construction and compaction shall conform to OPSS 314, September 1988.

* Designer Option:

The recovered material shall be processed with the underlying granular by mechanical means to a depth of _____**

Measurement for payment

Measurement for payment of recovered bituminous material on shoulders shall be in tonnes in conformance with OPSS 502, December 1983.

Basis of Payment

Payment at the contract price for the above work shall be full compensation for all labour, equipment and material required to do the work.

Designers Note: * Delete according to the recommendation of the Geotechnical Section.

** The depth of processing shall be such that the blended material shall contain no more than 40 % by volume of recovered bituminous material.

WARRANT: Always with this tender item.

IN PLACE PROCESSING OF BITUMINOUS PAVEMENT - Item No.

Special Provision No.399F35

June 1989

Processing and Compacting of Bituminous Pavement and Underlying Granular as Base Course

Scope

This special provision covers the work of processing existing bituminous pavement and underlying granular in place and compacting the processed materials as base course.

Construction

While processing the existing pavement, the Contractor shall ensure that the existing pavement and the granular base course are thoroughly mixed to the specified depth (see Designers Note).

* Location (Stn. to Stn.)	Pavement Type	Thickness	Process Depth
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The processing shall be carried out such that all the mixed material passes the 26.5 mm sieve and not more than 75 % passes the 4.75 mm sieve.

The surface of the processed material shall be bladed, shaped and compacted to produce the specified grade & cross-sections to conform to the requirements of OPSS 301. The material shall be compacted as specified in OPSS 501, December 1987. Scarifying and fine grading of the surface shall be carried out immediately prior to paving.

The processing, including compaction, shall be completed to the same station for the full pavement width prior to closing down operations each day. Full pavement width covers both directions for two lane highways and one direction for multi-lane highways.

Measurement for Payment

Measurement for the processed material is by Plan Quantity as may be revised by Adjusted Plan Quantity of the horizontal area in square metres.

Basis of Payment

Payment at the contract price for the above work shall be full compensation for all labour, equipment and material required to do the work.

- * Designers Note: The depth of processing shall be calculated according to the thickness of the existing pavement and shall be such that the blended material shall contain no more than 50 % by volume of bituminous material.

WARRANT: Always with this tender item.